Journal of Applied Animal Research

ISSN: 0971-2119 (Print) 0974-1844 (Online) Journal homepage: http://www.tandfonline.com/loi/taar20

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To cite this article: Renate Luise Doerfler, Wolfram Petzl, Anna Rieger & Heinz Bernhardt (2018) Impact of robot scrapers on clinical mastitis and somatic cell count in lactating cows, Journal of Applied Animal Research, 46:1, 467-470, DOI: 10.1080/09712119.2017.1336442

To link to this article: https://doi.org/10.1080/09712119.2017.1336442

Published online: 09 Jun 2017.

JOURNAL OF APPLIED ANIMAL RESEARCH, 2018
VOL. 46, NO. 1, 467–470
https://doi.org/10.1080/09712119.2017.1336442

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Impact of robot scrapers on clinical mastitis and somatic cell count in lactating cows

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ABSTRACT

The objective of the present study was to explore the impact of robotic walkway cleaning on clinical mastitis and the somatic cell count in lactating cows. Data collection was carried out on a large dairy farm for two six-month periods in 2012 and 2013. Walkway cleaning with five robot scrapers was performed only in 2013. The incidence of clinical mastitis was analysed using the chi-square test. A linear mixed-effects model was applied for the analysis of the somatic cell count. Results indicated that the proportion of incidences of clinical mastitis decreased between 2012 and 2013 by 2.42 percent points. On the other hand, the somatic cell count of the cows slightly rose between both investigation periods and thus increased the likelihood of intramammary infection. This contrary development between clinical mastitis and somatic cell count also occurred in previous studies in which it was attributed to a pathogen-specific effect owing to farm management. An investigation over a longer period can help to clarify the influence of robot scrapers on udder health in dairy cows.

ARTICLE HISTORY
Received 9 December 2016
Accepted 22 May 2017

KEYWORDS
Mastitis; somatic cell count; robot scraper; hygiene; dairy cow

Introduction

Mastitis is a bacterial infection of the mammary gland in dairy cows which negatively influences animal welfare and the physical–chemical composition of milk. It is a source of considerable milk loss and reduces the economic returns of dairy farmers worldwide. Earlier reports showed that daily milk loss is within a range from 0.35 to 4.70 kg and lactation milk loss between 165 and 919 kg (Hand et al. 2012). The treatment of cows with antibiotics causes additional costs and labour (Huijps et al. 2009).

Somatic cell count (SCC) of milk is the most important indicator of the level of intramammary infection and the severity of mastitis (Green et al. 2008; Hand et al. 2012). Infected animals may develop clinical mastitis (CM) with visible changes in milk. In contrast, subclinical mastitis lacks any visible signs of inflammation, but is identified by an increased SCC in the milk predominated by immigrating neutrophilic granulocytes (Green et al. 2008; Hand et al. 2012). Milk of healthy udders contains a SCC of <100,000 cells/ml, whereas diseased udders have a SCC between 100,000 and >10,000,000 cells/ml (Dohoo & Meek 1982; Green et al. 2008).

Previous studies showed that udder health and environmental hygiene are closely associated (Schreiner & Ruegg 2003; Köster et al. 2006; Breen et al. 2009). The presence of moisture and the accumulation of manure in the bovine environment are the major sources of poor hygiene and mastitis (Ward et al. 2002; Schreiner & Ruegg 2003). Thus, regular and frequent cleaning of walkways and cubicles is crucial in order to reduce the risk of intramammary infection.

Robot scrapers are increasingly used to remove manure from slatted floors and to improve the cleanliness of walking alleys. Following different routes, these battery-driven machines push the manure deposited on the floor surface down through the slats. It has not yet been investigated whether the use of robot scrapers has an impact on mastitis incidence. In the face of the current demand to reduce antimicrobial drugs in dairy production, the improvement of environmental hygiene becomes increasingly important.

Robot scrapers could be an appropriate means to reduce the risk of intramammary infection and mastitis in dairy cows. The objective of this study was to explore the impact of a robotic cleaning system on the incidence of CM and the SCC in lactating cows.

Material and methods

Study design, animals and farm

Data were collected retrospectively in a Holstein Friesian herd on a commercial dairy farm over two 6-month periods, in 2012 and in 2013. Herd size in the individual months ranged from 1247 to 1328 lactating cows. The first six months reflect the time prior to and the second six months the time immediately after the installation of five robot scrapers for the cleaning of walkways. Incidences of CM had been documented monthly in the herd management programme (HERDE, dsp agrosoft, Ketzin, Germany) by the farm staff. Data on the SCC were derived from the results of the monthly analysis of composite milk samples within the scope of the routine milk recording

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system. The mean daily milk yield was 29.13 kg per cow and the range of parity in the herd was from 1 to 11.

The animals were housed in a cubicle housing system on slatted floors and milked twice a day in a rotary milking parlour that was accessible via a central passageway. Silage-based ration was mixed in a stationary mixer and provided with a belt feeding system twice a day. Neither the animal environment nor the management practices (cubicle cleaning and milking practices) and the feeding regime were changed throughout both investigation periods. Walkways between cubicles had a width of 1.78 m, whereas walkways at the belt feeding system were 3.00 m wide.

Five robot scrapers were installed in the farm to clean the slatted floors. The external dimensions of the robots were 150 cm × 70 cm × 65 cm; a 120-cm-wide slide was mounted in front of the robot body. The robot scrapers moved at a speed of 5.5 m/min.

CM records and milk analysis

Cases of CM per month were identified immediately before milking by visual changes in milk (clots, colour and consistency), signs of local inflammation (udder swelling and pain) and systemic signs of disease (rectal temperature >39.2°C, general depression). Cases of CM were not categorized into mild, moderate and severe cases. The SCC in milk was analysed from composite milk samples on a monthly basis by Fossomatic® 5500 (FOSS, Rellingen, Germany).

Data management and analysis

Incidences of CM (data set 1) were analysed for significant differences in the first and second investigation periods using the chi-square test. A linear mixed-effects model was performed to identify the effects of year (i.e. robot scraper present or not), parity, daily milk yield and month on $\log_{10}$SCC (data set 2). Cow was included as a random effect in the model. Residuals were assumed to be independent and identically normal distributed. Prior to the analysis, a total of 15,320 records from 2208 different cows were screened for errors. Data of the SCC were $\log_{10}$-transformed owing to skewed distribution of the original data. Statistical analysis was carried out at the significance level $P < .05$ with the RStudio version 0.99.902 and the *R* version 3.3.1 using the nlme package version 3.1–128.

Results and discussion

Clinical mastitis

Results demonstrated a relationship between robotic walkway cleaning and infections of the mammary gland ($P < .001$). In the first investigation period 2012, 673 incidences of CM were counted, whereas in the second investigation period, only 499 cases occurred. The proportion of cows suffering from CM declined from 8.87% in 2012 to 6.45% in 2013 (Table 1). This decrease in udder infections took place in all months investigated.

Table 1. Number of observations, number of incidences of CM and proportion of incidences of CM by month in the first and second investigation periods.

	Year	Number of observations (*n*)	Number of incidences of CM (*n*)	Proportion of incidences of CM (%)
February	2012	1303	94	7.21
	2013	1315	91	6.92
March	2012	1264	76	6.01
	2013	1328	58	4.36
April	2012	1250	115	9.20
	2013	1262	69	5.55
May	2012	1257	111	8.83
	2013	1269	98	7.72
June	2012	1266	126	9.95
	2013	1288	100	7.76
July	2012	1247	151	12.11
	2013	1271	83	6.53
Total	2012	7587	673	8.87
	2013	7733	499	6.45

It is very likely that the positive impact on udder health is attributable to the cleaner surfaces of walking areas due to robot scraper operation. Previous studies showed that environmental hygiene is positively correlated with the reduced incidence of mastitis (Barkema et al. 1999; Ward et al. 2002; Köster et al. 2006; Breen et al. 2009). Moreover, the cleanliness of the cow and the udder affects the health of the mammary gland (Barkema et al. 1998a; Cook et al. 2002; Sant'Anna & Paranhos da Costa 2011; Zucali et al. 2011). The provision of clean and dry walking and lying areas is essential (Wenz et al. 2007), since it is important to minimize the transfer of pathogenic microorganisms from the surface of the lying or walking area to the teat ends to overcome poor udder health (Zdanowicz et al. 2004).

It is hypothesized that as a consequence of robot scraper operation, the contamination of bovine hooves and legs with faeces as well as the soiling of bedding decreased when animals entered the cubicle. According to preceding studies, the use of mechanical manure scrapers reduces the amount of manure contamination on slatted floors and has a positive impact on the cleanliness of the udder and teats. A higher frequency of manure removal improves cow cleanliness compared to a lower frequency (Schreiner & Ruegg 2003; Magnusson et al. 2008). Peeler et al. (2000) reported that the incidence of CM in dairy herds is reduced when the holding pen in front of the milking parlour is cleaned with a mechanical scraper at least twice a day.

Cubicle management has a substantial impact on udder health and milk quality, as suggested by Green et al. (2008) and Köster et al. (2006). It is, therefore, plausible that reduced contamination of bedding material by soiled hooves resulting from robot scraper operation improved the cleanliness of cows and udder health. In contrast, Nyman et al. (2009) identified no relationship between the frequency of cubicle cleaning and the provision of new bedding, and incidences of mastitis in primiparous cows. The reduced entry of faeces in the cubicle is conducive to drier bedding surface and it is agreed that the low moisture content of bedding material inhibits bacterial growth of environmental mastitis pathogens (Ward et al. 2002; O'Reilly et al. 2006). However, Hutton et al. (1990) in their experiment did not find any difference between the number of

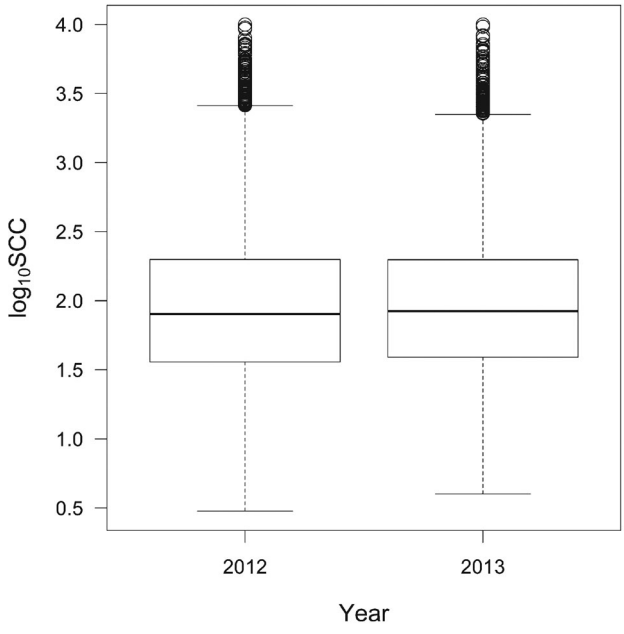

Figure 1. Boxplots showing the distribution of the logarithmized somatic cell count (log_{10}SCC) in the first and second investigation periods.

environmental pathogens in bedding with high or low moisture and the presence of mastitis.

Somatic cell count

Table 2 shows the regression coefficients, standard errors and *P*-values of the linear mixed-effects model for the log_{10}SCC. Although the incidence of CM decreased after the installation of the robot scraper in 2013, the SCC in dairy cows slightly increased ($P < .001$) compared to that in the same period of the previous year (Figure 1). This result was in agreement with Hultgren (2002) observing that in relation to housing changes from tie stalls to cubicles, a drop in the incidence of CM was not always accompanied by a clear decline in SCC and suggesting that the association between the presence of CM and SCC can vary. In this respect, Barkema et al. (1998b) identified a pathogen-specific effect, indicating a correlation between low incidence rates of CM caused by *Streptococcus agalactiae* in herds and a high SCC, assuming that this effect might arise from farm management practices. Another explanation for the SCC increase in 2013 could be that the robot scrapers as novel mobile objects in the animals' environment caused stress to the cows. Previous research showed that new environments can cause stress in cows (Bruckmaier et al. 1996; Grandin 1997). Moreover, earlier studies indicated that in herds with low SCC, both the cubicles and calving pens were cleaner (Barkema et al. 1998a; De Vlieger et al. 2012) and the bedding material had lower moisture content (Hutton et al. 1990). The analysis of Köster et al. (2006) revealed that the SCC was significantly associated with the hygienic conditions of cubicles, holding pens and floor of the milking parlour, but not with the hygiene of walkways. De Vlieger et al. (2004) and Green et al. (2007) stressed the importance of hygiene in dry cow accommodations and calving pens to avoid a rise in the SCC in bulk milk.

Table 2. Regression coefficients, standard errors and *P*-values of the linear mixed-effects model for the log_{10}SCC including year (i.e. robot scraper present or not), parity, daily milk yield and month as fixed effects and cow as random effect.

Effect	Regression coefficient	Standard error	*P*-value
Intercept	2.1844	0.0191	<.001
Year[a]	0.0339	0.0082	<.001
Parity	0.0965	0.0050	<.001
Daily milk yield	−0.0145	0.0005	<.001
Month March[b]	−0.0490	0.0118	<.001
Month April[b]	−0.0439	0.0120	<.001
Month May[b]	−0.0297	0.0120	.013
Month June[b]	−0.0549	0.0120	<.001
Month July[b]	0.0449	0.0121	<.001

[a]Reference: 2012.
[b]Reference: February.

The parity of the cows also had a positive effect ($P < .001$) on the SCC in the linear mixed model. These findings were consistent with previous studies demonstrating that the SCC (Schepers et al. 1997; Haskell et al. 2009) and the risk of CM (Smith et al. 1985; Green et al. 2007; Olde Riekerink et al. 2007) rose with increasing parity. However, these results were contrary to those of Osteras and Lund (1988) demonstrating that infections with coagulase-negative staphylococci had no association with cow age. These authors assumed that it is the duration of exposure to pathogenic microorganisms that predisposed the animal to chronic mastitis caused by contagious pathogens. Similarly, Laevens et al. (1997) found no significant effects of parity on SCC in bacteriologically negative cows.

In this study, the SCC declined with increasing milk yields of cows during the two 6-month periods ($P < .001$). Despite the unexpected increase in the SCC in the present study, the relationship between the SCC and the daily milk yield was in agreement with the majority of earlier studies. Previous studies illustrated that the herd SCC drops with an increase in the daily average milk yield (Lievaart et al. 2007; Haskell et al. 2009; Nyman et al. 2014). On the contrary, Lescourret et al. (1995) reported that the incidence of mastitis was higher in cows with higher milk yield.

Conclusion

The present results provided insight into the effects of a robotic cleaning system on udder health in lactating cows. They demonstrated that the incidence of CM in dairy cattle decreased as a result of automated cleaning of walkways by robot scrapers and thus had a positive effect on udder health. At the same time, the SCC slightly rose and increased the probability for subclinical mastitis and the risk of the subsequent development of CM. This opposite trend between CM and SCC was also observed elsewhere. However, it would also be conceivable that stress, induced by the newly introduced technology in the activity area of the animals, underlies these findings. Thus, the impact of the novel automated cleaning technology on the health status of the bovine mammary gland needs further clarification.

Acknowledgements

The authors would like to thank Christina Koestler and Annette Reimann for their assistance in data provision. They also gratefully acknowledge the

cooperation of the farm staff and thank Christina Lehermeier for the expertise and support with the statistics.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

This work was funded by budget funds of the Technical University of Munich.

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