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Management Factors Influencing Milk Somatic Cell Count and Udder Infection Rate in Smallholder Dairy Cow Herds in Southern Vietnam

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Abstract: The present study was conducted to investigate management factors influencing milk Somatic Cell Count (SCC) and udder infection rate in lactating cows housed at smallholder farms in Southern Vietnam. In total 115 lactating cows at 20 farms were included in the study. Management and milking routines were registered and quarter milk samples were taken for analysis of SCC and bacterial species. Watering routine was found to significantly influence herd milk SCC ($p = 0.008$) and the method of teat cup cleaning showed a tendency to influence herd milk SCC ($p = 0.078$). *Streptococcus agalactiae* was the most common bacteria species in all management groups. Cleaning teat cups with detergent at every milking was a routine observed to be associated with lower infection rate of *Streptococcus agalactiae*. The results of this study show the presence of several in-adequate management and hygienic practices associated with high SCC which if improved could lead to improved udder health and subsequently higher milk yield.

Key words: Lactating cows, quarter milk SCC, smallholder farms, *Streptococcus agalactiae*, associated

INTRODUCTION

Development of dairy production in Southern Vietnam is based mainly on smallholders. The number of smallholder dairy farms has increased and their production has shifted from integrated subsistence production systems to a new system based on milk production (Luthi *et al*., 2006). In a previous field study where the strengths and weaknesses in dairy management at farm level were investigated, it was found that dairy cows had high milk SCC with an average of 1.3 million cells mL^{-1} milk (Lam *et al*., 2010). This strongly indicates that the cows are suffering from severe udder health problems, since milk from a healthy udder is suggested to have SCC<100,000 cells mL^{-1} (Hillerton, 1999; Harmann, 2002).

Mastitis is still the most common and costly disease in dairy production. Mastitis can be present in both a clinical and subclinical form and is usually caused by bacterial infection of the mammary glands. Both mastitis forms are associated with increased milk SCC which is the most commonly used indicator of the inflammatory status of the mammary gland (Sandholm, 1995). Clinical mastitis is associated with external signs of inflammation such as swelling, tenderness and/or abnormal milk while subclinical mastitis exhibits no clinical signs and often remains undetected unless laboratory methods like SCC are used (Edmondson and Bramley, 2004). Management and milking practices are known to have an impact on udder health, mainly due to the fact that they expose the cows to factors predisposing for mastitis and udder infection (Barkema *et al*., 1999; Akers, 2002).

When dairy production was initially introduced in Vietnam hand milking was the most common milking practice but the use of the bucket machine has dramatically increased during recent years. Although, a high number of farmers attend training courses in dairy production (Lam *et al*., 2010), it is questionable if the farmers are trained and educated adequately for correct practice of machine milking, particularly regarding milking hygiene.

According to Pyorala (1995) contagious mastitis pathogens, like *Streptococcus (Str.) agalactiae* have their major reservoir in the infected udder from which they

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are spread among cows and between quarters, mainly during milking through the milking equipment used and/or the milkers' hands. Other udder pathogens, e.g., *Str. uberis* have their primary reservoir in the immediate environment of the cows but can per se also be spread from cow to cow during milking (Smith *et al*., 1985; Edmondson and Bramley, 2004).

It is reasonable to expect that inadequate milking routines, poor milking hygiene and unsuitable management practices could be the reasons for the high milk SCC observed among smallholder herds in Southern Vietnam but available information is scarce. Knowledge of the prevalence and distribution of mastitis pathogens as well as risk factors that are associated with the disease are critical to the prevention of mastitis.

The aim of this study was therefore to investigate, how management factors influence milk SCC and udder infection rate in lactating cows at smallholder dairy farms in Southern Vietnam. The bacteriological results and antibiotic resistance pattern are reported in detail by Lam *et al.* (2010).

MATERIALS AND METHODS

Selection of farms and cows: From March to April 2008, 40 farms all members of the Milk Production Promotion project (MPP) in Long Thanh district, Dong Nai province, Vietnam were visited and milk samples were taken for analysis of herd milk SCC. This was done 6 weeks before the study started.

Total 20 farms, representing both low and high herd milk SCC and fulfilling the criteria of having at least 6 lactating cows and using bucket machine milking were visited again, 1 week prior to the start of the study for analyses of herd milk SCC. Total 11 of theses farms had a herd milk SCC>400,000 cells mL^{-1} and 9 farms a herd milk SCC<400,000 cells mL^{-1}. According to Scharm *et al.* (1971) cows with SCC>400,000 cells mL^{-1} are positively correlated with subclinical mastitis and the EEC directive 92/94 states that milk with SCC>400,000 cells mL^{-1} may not be used for liquid milk and not even for human consumption after 1998.

Cows at the first week of lactation and those exhibiting mastitis symptoms were excluded. In larger farms (>6 cows), 6 lactating cows were selected at random per farm. The average number of cows per farm was 11±2.6.

The cows were F1-F4 crossbred Holstein-Friesian with a mix of red Sindhi-yellow cattle. Average milk yield and mean herd milk SCC were 13.4±4.6 kg/cow/day and 632,000±506,000 cells mL^{-1}, respectively. The study was conducted at the onset of the rainy season from March to June, 2008 when the weather was hot and humid. During this period, the rainfall was 800-1,300 mm and the average temperature was 30°C.

Data collection: The farms were visited once during the morning or evening milking for data collection and milk sampling. A protocol was used to record data on farm management practices and of individual cows. Farmers were asked about management routines including housing, feeding, milking practices and hygiene. Milking practices were observed during the entire milking use of water in different aspects (drinking water, cleaning barn, etc.) and cooling system, teat cleaning and teat cup cleaning were also recorded. Vacuum level was recorded when the cows were milked. Data for individual cows including breed and milk yield were obtained from the MPP administration office.

Milk sampling and analysis: After milking was completed, quarter strip milk samples were collected from 6 lactating cows per farm for analysis of SCC. About 25 mL of stripping milk from each udder quarter were collected in plastic bottles for analysis of quarter milk SCC using a DeLaval cell counter DCC (DeLaval, Tumba, Sweden). For bacteriological examination, quarter milk samples were taken by using a Mastistrips cassette (Mastistrip©, SVA, Uppsala, Sweden). The cassette is specially designed to minimize the risk of contamination and mix-up of udder quarters. The milk samples are dried and thereby stabilized to prevent growth of contaminating bacteria which is an advantage, particularly during long transport times to the laboratory (Nilsson *et al*., 1990). The cassettes were sent by courier to the Mastitis laboratory of the National Veterinary Institute (SVA), Sweden for identification of bacterial species according to the Laboratory's accredited methods.

Statistical analysis: Categorised data were coded according to the scores of each data set and engaged for analysis in the statistical model. To obtain a better fit to the normal distribution, the milk SCC were logarithm-transformed. However, the data is presented as geometric means in the results. Effects with a potential relation to SCC at the herd level were investigated by the linear model:

$$y_i = \mu + \alpha_{k_i} + \beta_{m_i} + \gamma_1 x_{i1} + \cdots + \gamma_5 x_{i5} + e_i$$

where, μ is the overall expectation, α_{ki}, β_{mi} and $\gamma_1 x_{i1},..,\gamma_5 x_{i5}$ correspond to the effect of teat cleaning before milking, teat cup cleaning after milking, cooling system, housing system, water routine, type of milking labor and vacuum

Table 1: Management routines and mean herd milk SCC (×1000 cells mL^{-1}) of 20 small holder dairy farms

Management factors	Category	No. of herds	Herd SCC Mean±SD
Drinking water[1]	*Ad libitum*	10	403±275
	Restricted	10	860±600
Vacuum pressure (kPa)	37-45	3	718±928
	>45	17	616±448
Housing system[2]	Tie stall	7	345±335
	Loose housing	13	786±786
Cooling system[3]	Spraying water	3	311±10
	Washing cows	17	667±528
Type of milker	Family	14	629±582
	Hired	6	636±334
Method of udder cleaning[4]	Water hose	10	591±512
	Water and hand	7	700±610
	Water and dry towel	3	603±403
Teat cup cleaning[5]	Only water each milking	6	546±270
	Water each milking plus detergent 2 times $week^{-1}$	11	774±625
	Detergent at each milking	3	279±164

[1]*Ad libitum*: the water troughs were placed in the middle/corner of the barn and the cows had free access to fresh water, restricted; the troughs were filled after concentrate feeding before/or during milking and additionally or troughs filled with water several times each day. [2]Tie stall: the cows were tethered and standing in the stall for the whole day; loose housing: the cows were only tethered when milking. [3]Spraying water: water was sprayed to cool the roof at the hottest time of the day; washing cows; the cows were sprayed with water before or between milkings. [4]Water hose: the farmers used a water hose to flush the cows and udders before milking; water and hand; farmers use a water hose and their hands to clean udders before milking; water and dry towel; the farmers used water to flush the udders and then dried the udder by one towel in common use for all cows in the farm. [5]Only water each milking: the farmers used only water to clean the teat cups after milking; water each milking plus detergent 2 times $week^{-1}$; the teat cups were cleaned after each milking and detergent was used twice a week; detergent at each milking; the farmers used detergent when cleaning the teat cups after every milking

pressure level, respectively. The first 2 variables were defined as class variables with 3 levels and the last 5 variables with 2 levels were modelled as regression effects. The complete model was reduced by successively removing the least significant effect until only those significant at level 0.1 remained. Procedures of SAS (SAS Institute Inc., 2008) were employed to perform the numerical calculations for the model above. The statistical package was also used for descriptive statistics of data on bacterial infection of cows and of quarters. Seven variables associated with management routines were tested in the model (Table 1).

RESULTS AND DISCUSSION

Management routines and herd milk SCC: Table 1 shows management routines practiced at the farms included in the study and geometric means of herd milk SCC. The access to drinking water was found to significantly influence milk herd SCC ($p = 0.008$). In herds providing drinking water *ad libitum* the measured herd milk SCC was lower (403,000 cells mL^{-1}) than in herds where the cows were offered drinking water restrictedly (860,000 cells mL^{-1}). The method of teat cup cleaning had a tendency to influence herd milk SCC ($p = 0.078$). Farms using water and detergent to clean the teat cups after each milking showed a lower herd milk SCC (279,000 cells mL^{-1}) compared with farms where the teat cups were cleaned with only water after each milking (546,000 cells mL^{-1}) and farms where the teat cups were additionally cleaned with detergent twice a week (774,000 cells mL^{-1}). The average vacuum level at the farms was 49.0 kPa, ranging from 37.3-53.3 kPa. Most of the farms (17) had a vacuum level of >45 kPa but in the statistical model, it was not found to significantly influence herd milk SCC ($p = 0.552$).

Bacterial isolates: Table 2 shows the frequencies of isolated bacteria species by cow and quarter in herds with different management routines. *Str. agalactiae* was the predominant species in all management groups. Herds, where water was provided *ad libitum* showed a higher percentage of quarters with *Str. agalactiae* infection (26%) compared with herds where water for the cows was restricted (16%).

In herds where teat cups were cleaned with water and detergent after each milking, the quarter infection rate of *Str. agalactiae* was low (3%) compared with those cleaning teat cups only with water (18%) and those cleaning with water and additionally with detergent but only twice a week (27%). Herds with a milking vacuum of >45 kPa showed a higher percentage of quarters with *Str. agalactiae* infection (21%) compared with herds with a milking vacuum of 37-45 kPa (13%).

Farms where water and a dry towel were in common use for all cows for cleaning teats prior to milking showed the highest percentage of quarters with *Str. agalactiae* infection (31%) compared to the other teat pre-milking cleaning practices. The routines for cleaning teat cups without using detergent after each milking as well as cleaning the udders/teats pre-milking and cooling the cows using a water hose were found to be associated with high frequencies of quarter milk samples with growth of Coagulase-Negative Staphylococci (CNS) and *Str. uberis*, respectively. The results of this study indicate that access to drinking water is a management factor influencing herd milk SCC. The highest herd milk SCC was noted in farms where drinking water was provided restrictedly compared with the farms where drinking water was given *ad libitum*. The reason for this is not clear and could only be speculated on. Firstly, there was no difference in the milk yield between the two groups. Thus, it is not likely that a concentration effect on the milk SCC could explain the higher SCC in cows with restricted access to water. The amount of water the cows were offered and drank was not

Table 2: Frequency of infected cows (n = 115) and quarters (n = 458) by isolated species and management routines

Factors	Category	No. of herds	No. of cows	No. of quarters	Infected cows/quarter (%)					
					Str. agalactiae	*Str. uberis*	*Str. dysagal.*	*Str.* sp.	*S. aureus*	CNS
Drinking water	*Ad libitum*	10	56	224	43/26	13/5	4/1	2/1	7/2	16/6
	Restricted	10	59	234	29/16	15/7	2/0	0/0	3/1	22/8
Vacuum pressure	37-45	3	17	68	24/13	6/3	0/0	0/0	0/0	24/10
(kPa)	>45	17	98	390	38/21	15/6	3/1	1/1	6/2	18/ 6
Housing system	Tie stall	7	40	160	35/21	8/4	3/1	0/0	8/3	15/6
	Loose housing	13	75	298	36/21	17/7	3/1	1/1	4/1	21/7
Cooling systems	Spraying roof	7	12	48	67/40	0/0	0/0	0/0	8/4	8/2
	Washing cow	13	103	410	32/19	16/7	3/1	1/1	5/1	20/7
Type of milker	Family	14	79	315	34/20	14/5	4/1	1/1	5/1	23/8
	Hired	6	36	143	39/22	14/7	0/0	0/0	6/2	11/4
Method of	Water hose	10	59	235	32/20	17/7	3/1	0/0	5/1	19/7
cleaning udder	Water hose and hand	7	39	156	33/19	15/7	3/1	3/1	8/3	26/8
	Water and dry towel	3	17	67	53/31	0/0	0/0	0/0	0/0	6/2
Method of	Only water/milking	6	34	136	32/18	24/10	3/1	3/2	6/2	24/10
cleaning teat cup	Detergent 2 times week^{-1}	11	65	259	45/27	8/3	3/1	0/0	6/2	17/5
	Detergent at each milking	3	16	63	19/3	19/10	0/0	0/0	0/0	19/8

measured in the present study. However in a previous field study, it was found that only 36% of dairy farmers provided fresh water *ad libitum* while 52% provided <30 L water per cow and day (Lam *et al*., 2010). Thus, researchers could assume that the cows offered water restrictedly in the present study were drinking not more than approximate 30 L water per cow and day. In practice, many farmers routinely fed concentrates and provided drinking water in the same trough. They mixed water with concentrates and then the trough was filled with water after feeding the concentrates. Consequently in many cases, the water fermented and the cows refused to consume it. This practice may imply that inadequate management and tropical environmental conditions impair the cow's immune system.

Lactating cows in the tropics obviously need more water to alleviate heat stress and to increase water metabolism (Beede and Collier, 1986). Particularly in hot climates, cows increase water intake not only to replace water lost via sweat, respiratory evaporation, faeces and milk (Beede, 2005) but also to cool their body (Beede and Collier, 1986; Beede, 2005).

According to Chase (1988) restricted water intake resulted in reduced urine output, infrequent drinking activity, reduced feed intake and also influenced the normal physiological activity of lactating cows such as increased of blood packed cell volume hemotocrit and osmolality. It has further been confirmed that providing adequate drinking water for lactating cows reduced the impact of heat stress on milk constituents and milk SCC (Fielding and Mathewman, 2004).

Unexpectedly, a higher frequency of quarters with *Str. agalactiae* infection was observed at farms where water was provided *ad libitum*. It is difficult to find a reasonable explanation for this result considering the negative impact on the cow's general condition and milk SCC of inadequate water intake. Among each group of farms with different watering routines, other management routines that are known to influence the rate of spreading of udder infections, e.g., vacuum pressure, udder/teat cleaning before milking, etc., were on the whole, evenly distributed.

The milking machine can act as a transmitting vector of bacteria from cow to cow and within cow by quarter to quarter infection during the milking process. Numerically lower herd milk SCC was observed at the farms where teat cups were washed with water and detergent after each milking compared with the other teat cup cleaning practices. The cleaning procedure was that teat cups were washed by the physical cleaning action of air and water, assisted by detergent chemicals. In these herds also, the infection rate of *Str. agalactiae* was lower (Table 2). Blowey and Edmonson (2010) stated that careless cleaning routines of teat cups resulted in milk residue and bacterial build-up within the teat cup.

Unstable vacuum levels in combination with moderate cyclic fluctuation have been reported to increase new infection rates of mastitis (O'Rourke, 2004). A high vacuum level is known (Hamann *et al*., 1993) to influence teat tissues negatively and increase the risk for oedema in the teat. Bramley *et al*. (1992) reported that high vacuum levels induce teat orifice damage, leading to an increase of mastitis occurrence and SCC in dairy cows. In the present study, the vacuum level of the bucket machines was high, on average 49 kPa but with a wide variation among the studied farms. Vacuum gauges of the bucket machine units were not of the same brand and were usually installed by the farmers. The pressure varied during the milking process because of poor quality, fluctuation in the electricity supply during milking and the variation in experience of operating bucket milking machines. In contrast to other reports in this study

vacuum level was not a factor shown to significantly influence herd milk SCC. However, a milking vacuum of >45 kPa was observed to be associated with a higher percentage of quarters infected with *Str. agalactiae* (21%) compared with a milking vacuum of 37-45 kPa (13%). *Str. agalactiae* infections are usually considered to be associated with high SCC and it is surprising that in the present study vacuum level was not found to have any impact on herd SCC.

The explanation could be that in subclinical *Str. agalactiae* infections, the SCC may vary considerably from day to day (Salniemi, 1995; Keefe, 1997) and the herd milk SCC data are from a sample taken a week before quarter milk was sampled for bacteria identification. Additionally, due to the variations in vacuum during milking the measurements taken might not be fully representative of the mean vacuum the udder was exposed to during the whole milking process. The number of herds in the low vacuum group was small compared with the number in the high vacuum group which might also have influenced the result.

Cooling the cows and cleaning udder and teats before milking using a water hose and/or hand was associated with high percentage of quarters infected with CNS and *Str. uberis*, respectively. Coagulase-negative Staphylococci species have been isolated from the skin of cows and like *Str. uberis* also from the environment (White *et al*., 1989; Taponen *et al*., 2007). Environmental pathogens may contaminate the cow's body surface. According to Koster *et al*. (2006) use of water to clean the cows and udders before milking has been associated with high SCC because water fluxing along the udder can carry bacteria to the tip of the teat thereby increasing the risk of mastitis.

Str. agalactiae was the most common pathogen isolated while *Staphylococcus* (*S.*) *aureus* was found at a lower frequency in this study. This is in contrast to reports by several researchers in studies in tropical areas (Lafi *et al*., 1994; Almaw *et al*., 2008; Getahun *et al*., 2008). *Str. agalactiae* is a highly contagious bacteria species that exhibit properties enabling it to become persistent and easily develops into subclinical mastitis which was the only form of mastitis investigated in the present study. *Str. agalactiae* spreads rapidly between cows and quarters within the udder in particular during milking through the equipment used (Pyorala, 1995). In the absence of good udder hygiene and effective control measures most animals in any large dairy cow population will become infected. Among the smallholder dairy farms studied, milking hygiene was neglected and several factors found in milking routines, hygiene and equipment are well known to enhance the spread of contagious microorganisms. It may be studied that the prevalence of subclinical mastitis based on herd and udder quarter SCC was high in this study and that *Str. agalactiae* appears to be a significant mastitis pathogen behind this.

CONCLUSION

The results of this study show that management routines for drinking water had a significant influence and the method of cleaning teat cups showed a tendency to influence milk SCC. The use of detergent after each milking was associated with lower herd SCC and frequency of *Str. agalactiae* isolates.

RECOMMENDATIONS

It is recommended that cows at smallholder farms should be provided with drinking water *ad libitum* and that teat cup cleaning is conducted more thoroughly using detergent after each milking to reduce bacterial infections and milk SCC. The high levels of *Str. agalactiae* in all management groups emphasize that milking hygienic practices in particular should be improved in order to improve udder health, milk yield and economy of smallholder dairy farmers in Southern Vietnam.

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