Mac Vet Rev 2012; 35 (2): 55-64

Available online at
www.macvetrev.mk

Original Scientific Article

UDC: 636.2.09:618.19-002

UDDER QUARTER RISK FACTORS ASSOCIATED WITH PREVALENCE OF BOVINE CLINICAL MASTITIS

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Received 27 March 2013; Received in revised form 17 May 2013; Accepted 23 May 2013

ABSTRACT

A cross sectional study was carried out to estimate prevalence of clinical mastitis on udder quarters level and to determinate the quarter risk factors associated with the development of clinical mastitis during lactation.
The individual risk factors included assessments of parity, season of year when case of clinical mastitis was occurred, conformation characteristics of udder quarters and teats and distance from front and rear teat end to the floor. Cows with clinical mastitis were detected by clinical examination of the udder quarters and determination of abnormalities in milk.
The quarter level prevalence of clinical mastitis was 15.06% per lactation, out of which 3.32% were front left, 3.10% front right, 4.28% rear left and 4.28% were rear right quarters. The prevalence of udder quarters affected with clinical mastitis tended to increased with increasing the parity, from cows in first to the third parity, and then begins to decline slightly. The rear quarters frequently manifested form of clinical mastitis (49.39%) in relation to the front one (33.04%), and in 17.55% of the cases there were affected either, front and rear quarters. In the most cases of clinical mastit there was affected only one quarter of the mammary gland (74.35%), two quarters in 20.13%, three quarters to 3.61% and four quarters were affected in 1.89% of the cases of clinical mastitis.
The method of General Linear Model, unvaried procedure, revealed that prevalence of clinical mastitis on quarter level significantly ($p<0.01$) differed with the season of year when case of clinical mastitis was occured and scoring categories for position of rear udder quarters.

Key words : bovine mastitis, udder quarters, risk factors.

INTRODUCTION

Efficient production of high quality milk is challenged when udder health problems occur. Despite huge efforts, and although progress has been made, udder health still is an important issue on the dairy farms throughout the world (1). In general, the rate of intra-mammary infection is established by a combination of exposure of the teat-end to pathogens and the effectiveness of the defense mechanisms of the cow. Therefore, the teat is considered the first line of defense against clinical mastitis, so the changes in teat tissue around the teat canal may favor penetration of bacteria into the udder (2). The smooth muscles surrounding the teat duct should be contracted and the teat canal tightly closed between milking to impede bacterial passage from the teat orifice into the interior of the gland (3).

It is well established that a favorable association exist between mastitis resistance and several udder type traits. Previous work (4, 5) has indicated that various udder characteristics (low udders, wide teats, large teats, flat teat ends, and fast milking speed) are associated with increased mastitis incidence. These characteristics may be important because they increase the chance of injury and exposure to pathogens from the cow's environment. From the other side, cow factors like udder anatomy, teat-end shape, teat position, teat length, milk production, lactation stage, and parity influence teat-ends condition (6).

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However, most of this research has been directed at factors affecting mastitis in general without regard to which quarter or how many quarters might be affected. Several previous studies have evaluated aspects of intra-mammary infection based on the assumption that quarters within cow were independent of each other and an equal probability existed that either quarter may become infected (7, 8). However, other studies (9, 10) have shown that quarters are more alike within cows than would be expected assuming independence between quarters.

The objective of this study was to describe the distribution of the cases of clinical mastitis across udder quarters and to evaluate the effects of some risk factors on the development of clinical mastitis during lactation.

MATERIALS AND METHODS

This study was carried out in a three dairy farms located in Republic of Macedonia. Each of these farms differs in the systems and technology of rearing, the size of the herd, hygiene management and health management. During the study period, there were followed a total of 1267 lactations.

The researches were divided in four seasons during the year, according Trajcev (11).

The performed field-based research was made by analyzing of data for clinical mastitis occurrence and determination of potentional individual cow risk factors on udder quarters level.

The incidence of new cases of clinical mastitis was recorded daily, during the whole period of research, according to ordinary clinical methods under normal field conditions. Cows with clinical mastitis were detected by clinical examination of the udder [rubber, tumour, colour, dolour and *function laesa*] and determination of abnormalities in milk [presence of watery milk, flakes, clots, blood, pus, discoloured milk, etc]. Mastitis occurrence was expressed as prevalence of affected udder quarters on 100 lactations, calculated by equation:

$$\textit{prevalence rate on quarters level [\%]} = \frac{\textit{number of affected quarters}}{\textit{total number of opserved lactations}} \; x100$$

Within the same lactation, to distinguish two consecutive cases of clinical mastitis the period of nine days was used, respectively four days antibiotic treatment of affected quarters of mammary gland, another four days when the antibiotics persist in milk and in that period milk was waved aside, and the ninth day when there was not any abnormal change in the milk (12).

As possible risk factors for development of clinical mastitis during lactation and its distribution between udder quarters were followed:

- cow parity;
- season of the year when case of clinical mastitis was occurred;
- conformation characteristics of front and rear udder quarters;
- conformation characteristics of front and rear udder teats;
- measurement of the distance from teat end to the floor;

Parity of cows was calculated from the number of consecutive cow's lactation. Ages of observed cows were from the first to the sixth and more lactations.

Season of the year when case of clinical mastitis was calculated respectively with the four seasons during year: 091 [spring - 1 March 2009 until 31 May 2009], 092 [summer - 1 June until 31 August 2009], 093 [fall - 1 September until 30 November 2009] and 094 [winter - 1 December 2009 until 28 February 2010].

The udder conformation traits were classified according the criteria described by Dentine and McDaniel (13) and Seykora and McDaniel (14). There were five scoring categories for:

- position of front udder quarters;
- position of rear udder quarters and
- strength of ligamentum suspensor mamma.

The conformational characteristics of udder teats [papila mammae] were described with scoring system, separately for:

- teat end shape, two scoring categories, according Bakken (15) and Slettbakk et al. (16);

- teat shape and placement, five scoring categories, according Sapp et al. (17).

  The distance between the floor and udder teats end was measured in centimeters, separately for:
- shortest distance from front teats end to the floor, according Seykora and McDaniel (14) and Slattbakk et al. (16);
- shortest distance from rear teats end to the floor, according Seykora and McDaniel (14) and Slattbakk et al. (16);

During the survey period all measurements of udder and teats traits were repeated three times. All measurements and the data collection were made by same person in exactly the same way.

Statistical procedures were conducted in statistical software SPSS 11.0 for Windows. Unvaried associations between the response variable and each of the factors and covariance for the shortest distance from front and rear teats end to floor were studied using unvaried procedure of GLM-General Linear Model. Dependent variable in this analysis was prevalence of clinical mastitis on quarter level and its distribution between front and rare udder quarters.

Analysis of variance was made according model:

$Y_{ijklmnopqr}=\mu+P_i+YS\_CM_j+UF_k+UR_l+UL_m+TF_n+TR_o+PF_p+PR_q+b_r[df+dr]+e_{ijklmnopqr}$

$Y_{ijklmnopqr}$ = calculated value for prevalence of clinical mastitis on quarter level;

μ = average;

P_i = cow parity [j = 1, 2, 3, 4, 5, 6];

YS_CM_j = year season when case of clinical mastitis was occurred [k = 091, 092, 093, 094];

UF_k = position of front udder quarters [l = 1, 2, 3, 4, 5];

UR_l = position of rear udder quarters [m = 1, 2, 3, 4, 5];

UL_m = strength of ligamentum suspensor mamma [n = 1, 2, 3, 4, 5];

TF_n= front teat end shape [o = 1, 2];

TR_o= rear teat end shape [p = 1, 2];

PF_p= front teat shape and position [q = 1, 2, 3, 4, 5];

PR_q= rear teat shape and position [r = 1, 2, 3, 4, 5];

b_r[df+dr] = regression coefficient for covariance of measured distance from front and rear teats end to floor;

$e_{ijklmnopqr}$ = error.

RESULTS

Distribution and annual prevalence of clinical mastitis on udder quarters level, calculated per 100 lactations, is shown in Table 1. The corresponding rates expressed as a percentage are included also, assuming that each cow had four functional udder quarters.

Table 1. Annual prevalence rate of clinical mastitis on quarter level per 100 lactatio

Farm	Affected udder quarters										Healthy quarters	Total observed quarters
	FL*		FR*		RL*		RR*		Totally affected quarters			
	n	prevalence	n	prevalence	n	prevalence	n	prevalence	n	prevalence		
1	14	1,71%	14	1,71%	18	2,20%	20	2,45%	66	8,09%	750	816
2	124	7,61%	114	7,00%	126	7,73%	130	7,98%	494	30,34%	1134	1628
3	31	1,18%	30	1,14%	74	2,82%	68	2,59%	203	7,74%	2421	2624
Total	169	3,32%	158	3,10%	218	4,28%	218	4,28%	763	15,06%	4305	5068

*****FL= front left quarter; FR = front right quarter, RL = rear left quarter, RR = rear right quarter

The largest annual prevalence was calculated in dairy herd in Farm 2 [30.34%] compared with approximately the similar prevalence in Farm 1 [8.09%] and Farm 3 [7.74%]. The total prevalence of clinical mastitis for entire observed udder quarters, calculated per lactation was 15.06%. The total prevalence for front left quarters level was 3.32%, for front right was 3.10%, for rear left quarters was 4.28% and for rear right quarters was 4.28%. The clinical mastitis rate was higher for rear quarters than for front when all cases in all lactations were included. Rates did not differ between left or right quarters.

The annual prevalence of clinical mastitis in dairy farms on quarter's level, calculated per 100 lactations, separately for cows in different parity, is shown in Table 2.

Table 2. Annual prevalence rate of clinical mastitis on quarter level calculate for cows in different parity

	Parity						
Farm	1	2	3	4	5	6≥*	Total
1	7,14%	6,40%	4,79%	11,03%	12,50%	12,50%	8,09%
2	24,81%	30,93%	35,42%	36,73%	20,00%	25,00%	30,34%
3	4,15%	9,01%	7,93%	11,34%	10,80%	19,12%	7,74%
Total	10,86%	16,03%	18,82%	18,19%	12,96%	17,68%	15,06%

*cows in sixth and more lactations or parities

According to the results, the total annual prevalence of clinical mastitis on quarter level, per 100 lactations, was 15.06%. It seems that the prevalence of clinical mastitis, regardless farms, increased with increasing the parity, or consecutive lactation, beginning from cows in the first lactation [10.86%] up to cows in the third lactation [18.82%], and than decline slightly.

In Table 3 is shown the number of affected udder quarter per case of clinical mastitis.

Table 3. Number of affected udder quarters per case of clinical mastitis during observed period

Farm	Cows with one affected quarter per case of CM*	Cows with two affected quarters per case of CM*	Cows with three affected quarters per case of CM*	Cows with four affected quarters per case of CM*	Total number of cows with CM*
1	39	8	4	0	51
	76,47%	15,68%	7,84%	0	100,00
2	300	72	11	6	389
	77,12%	18,50%	2,82%	1,54%	100,00
3	93	37	6	5	141
	65,95%	26,24%	4,25%	3,54%	100,00
Total	432	117	21	11	581
	74,35%	20,13%	3,61%	1,89%	100,00

*clinical mastitis

From analysis of showed results in Table 3, there might been noticed that mostly of the cows in all three farms have had one quarters involved per case of clinical mastitis, and the number of cases per cow with two, three or all four involved quarters of mammary gland are drastically lower.

In Table 4 and Figure 1 are shown the results from analysis for the prevalence of affected front and rear quarters per case of clinical mastitis.

Table 4. Distribution and prevalence of affected front and rear quarters per case of clinical mastitis

Farm	Front quarters	Rear quarters	Front and rear quarters	Total number of CM* cases
1	16	26	9	51
	31.37%	50.98%	17.64%	100,00%
2	154	173	62	389
	39.60%	44.50%	15.90%	100,00%
3	22	88	31	141
	15.60%	62.40%	22.00%	100,00%
Total	192	287	102	581
	33.04%	49.39%	17.55%	100,00%

*clinical mastitis

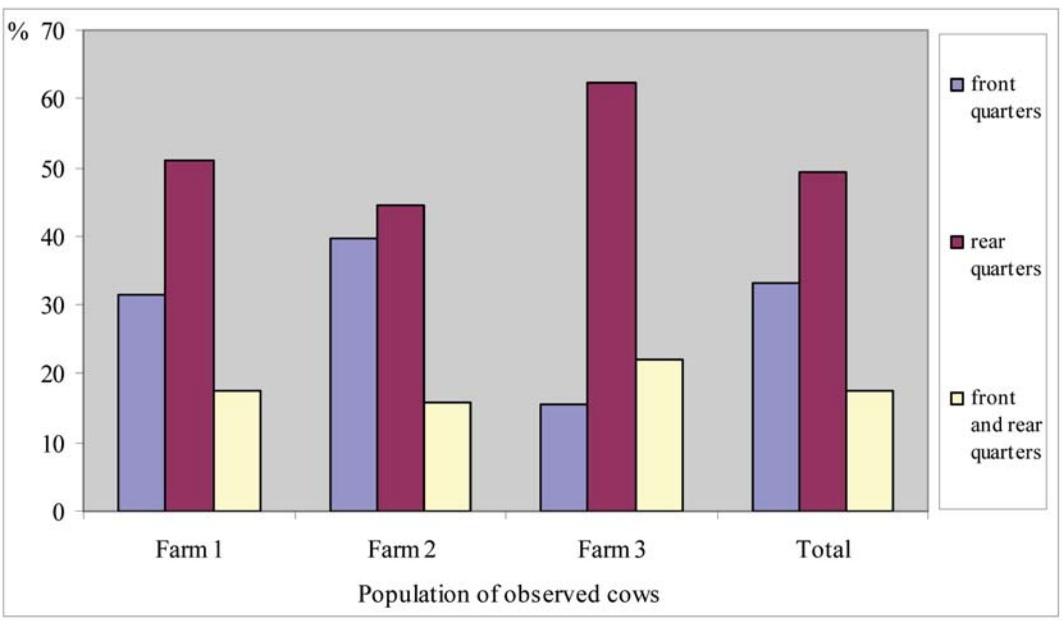

Figure 1. Distribution of affected front, rear and either front and rear quarters per case of clinical mastitis

Estimation of interdependence between variables in the statistical model was performed with Pearson's coefficient of correlation, showed in Table 5.

Table 5. Pearson's coefficient of correlation

Pearson's	L	SY_CM	Q_CM	UF	UR	UL	TF	TR	PF	PR	DF	DR
L	1	0.109**	0.120**	0.307**	0.384**	0.403**	-0.008	0.010	0.335**	0.348**	-0.515**	-0.520**
SY_CM		1	0.110**	0.056	-0.018	-0.012	0.035	0.060	0.065	0.126**	-0.014	-0.029
Q_CM			1	0.174**	0.181**	0.182**	0.010	-0.002	0.030	0.048	-0.151**	-0.167**
UF				1	0.788**	0.759**	-0.069**	-0.053*	0.232**	0.238**	-0.406**	-0.428**
UR					1	0.932**	-0.051	-0.031	0.266**	0.273**	-0.479**	-0.504**
UL						1	-0.036	-0.029	0.293**	0.303**	-0.511**	-0.501**
TF							1	0.781**	0.057*	0.052*	0.014	0.012
TR								1	0.066**	0.062*	-0.005	0.001
PF									1	0.916**	-0.355**	-0.350**
PR										1	-0.366**	-0.373**
DF											1	0.980**

** significant at the $p<0.01$ level

* significant at the $p<0.05$ level

There was statistical significant positive correlation between prevalence of affected udder quarters, season of year when case of clinical mastitis was occurred and conformation characteristics of udder quarters but negative correlation was existed between affected quarters and distance from front and rear teats end to the floor. This was meaning how udder characteristics become the worst at the same time there was increasing the number of affected udder quarters per case of clinical mastitis. With elapsing the seasons of year, from the spring to the winter, the prevalence of affected rear udder quarters was increasing. Pearson's coefficient of correlation showed that with increasing cow parity the udder and teat traits become worst and at the same time decreasing the distance between the floor and teats end.

In Table 6 is shown the statistical analysis used for determination of quarter risk factors associated with the development of clinical mastitis during lactation and its distribution between quarters of mammary gland.

Table 6. Influence of variables on development and distribution of clinical mastitis between front and rear udder quarters

Dependent variable: prevalence of affected front versus rear udder quarters			
Source of variations	df	Mean square	F-value
Model	33	50.181	113.008***
P	5	0.355	0.779
YS_CM	3	1.823	4.106**
UF	4	0.268	0.604 ^{NS}
UR	4	1.428	3.217**
UL	4	0.993	2.235 ^{NS}
TF	1	0.376	0.846 ^{NS}
TR	1	0.330	0.744 ^{NS}
PF	4	0.168	0.379 ^{NS}
PR	4	0.263	0.593 ^{NS}
DF	1	0.008	0.020 ^{NS}
DR	1	0.099	0.224 ^{NS}
e	455	0.444	
Total	488		
R^2 = 0.883			

*** significant at the $p<0.001$ level

** significant at the $p<0.01$ level

^{NS}no significance

Statistical model showed that there was a significant influence at level $p<0.01$ for the season of year and rear udder quarters conformation characteristics on development and distribution of clinical mastitis between quarters. Other variables did not show statistical significant influence as risk factors. Value for $R^2 = 0.883$ in the model was high, which meaning that variance for prevalence of clinical mastitis on quarter level can be explained with source of variations.

DISCUSSION

Reducing the incidence of clinical mastitis and number of affected udder quarters would benefit cows, farmers and dairy processors by increasing health and reducing losses as well as easing consumer concern about animal welfare and the use of antibiotics in dairy production. This study has shown that some quarter level risk factors are important in influencing the risk of clinical mastitis during lactation and indicate a differing susceptibility between front and rear udder quarters.

According our results, annual prevalence of clinical mastitis was a little lower with that reported from Kossaibati et al. (18) and Peeler et al. (19), when the incidence rate of clinical mastitis was 35 to 45 affected quarters on 100 lactations/year. The higher prevalence of clinical mastitis in the hind quarters agrees with previous studies in which the rear quarters are 1.5 to 5 times more prevalent than front one (9, 20). During the 4-year retrospective research of Shpigel et al. (21), performed in seven Israeli dairy herds, there were found a total of 1190 quarters affected with clinical mastitis in 1089 cows. The rear quarters had had a higher incidence risk (64.7% of quarter cases) than the front quarters. The distribution of affected quarters in that research was: 33.5% for rear right quarters, 31.2% for rear left, 18.2% for front right and 17.1% for front left quarters. Miltenburg et al. (22) reported that 31.1% and 33.2% of identified cases of clinical mastitis occurred in the right hind and left hind quarters, respectively, compared to 19.1% and 16.6% of clinical cases occurring in the right front and left front quarters, respectively. According to the one previous research performed in dairy herd in R. Macedonia (23), the prevalence of sub clinical mastitis on rear quarters level was 60.61%, and on front quarters level was 39.39%. The higher prevalence rate of clinical mastitis in the rear udder quarters may be due to their lowest position in relation to front one, which make them more prevalent to injures or damage and also the greater milk yield produced by the rear quarters, because prevalence of mastitis tends to increase with increases in milk production which is also risk factor for mastitis in dairy cows (24).

According several studies (4, 5, 13, 16) cows with less desirable shaped udders and more depth udder are more susceptible to lesions and contamination by a mastitis causing pathogens which increased the risk for mastitis occurrence. In their review, Seykora and MacDaniel (14) reported that asymmetric balance between fore and hind mammary quarters and udder depth increasing with parity increasing. Herewith these, with increasing of cow parity also increase the incidence risk for clinical mastitis (21, 25). Udder and teat morphology is very heritable (26) and could serve as a marker trait for selection to reduce mastitis in dairy cattle. According Lancelot et al. (27), the only significant factor that influence the distribution of affected udder quarters was cow parity, while the udder conformation did not show significant influence. There are no consensus in literature data about influence of teat morphology on mastitis occurrence, but these is not stell too clean (28, 29). According Hickman (30) the cows with small round and pointed teat are more resistant to mastitis, but Lojda et al. (31) did not find statistical connection between teat morphology and mastitis resistance. According Van de Geer et al. (32) cows with small, pointed teat tip have been more resistant to mastitis compare to cows that have plate, funnel or inverted teat-end shape. However, more researchers from that period (33, 34) have agreed that cows with inverted teat end shape have a higher incidence of mastitis in relation to cows with pointed teat end shape. Concerning the relationship between teat size and mastitis, Hickman (35) reported incidence of mastitis increased proportionally to teat diameter, and also he noticed that cows with shorter teats had higher milk production.

According our results, the distance between teat ends is not the possible explanation for the frequency distributions observed. Jensen et al. (36) stated that decreasing teat end to floor distance was associated with increased incidence of clinical mastitis. Although, they found a negative correlation between incidence of clinical mastitis and teat tip to floor distance, but positive correlation between incidence and teat length, teat placement and milk flow rate. However, Ronningen and Reitan, (37) found no significant associations between teat-end to floor distance and clinical mastitis incidence. The probability of distribution and incidence of clinical mastitis on quarter level vary between differing teat shapes, sizes and teat end callosity (6).

Rahman et al., (38) found that seasonal variations during year statistically significant influence on incidence and distribution of clinical mastitis between udder quarters. O'Driscoll et al. (39) suggested that the amount of environmental moisture represented by daily rainfall had the greatest impact on animal and bedding hygiene and moist manure is more likely to adhere to an animal's coat. Indeed, occurrence of completely wet and soiled floor is risk factor for poor hygiene in the stalls and potential source for mastitis organisms to enter the udder through the teat orifice.

Knowledge of possible relationships or dependencies between quarters within cows relative to mastitis is important. Batra et al. (40) looked at correlations between proportions of mastitis in one quarter and other quarters and differences between front and rear quarters. Several studies have evaluated aspects of intra-mammary infection based on the assumption that quarters within cow were independent of each other and an equal probability existed that either quarter may become infected (7, 8). Results that were publishing by Adkinson et al. (9) and Van Dorp et al. (10) have shown that quarters within a cow are more alike with respect to clinical mastitis than would be expected if assuming independence between quarters. Finally, Berry and Meaney (41) leaved the model of independent distribution and illustrated a strong interdependence between quarters for sub clinical and clinical mastitis.

Knowledge of the factors responsible for dependency between quarters concerning mastitis might provide better understanding of the disease process and may help to identify or resolve problems related to milking management, environment or the milking machine.

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