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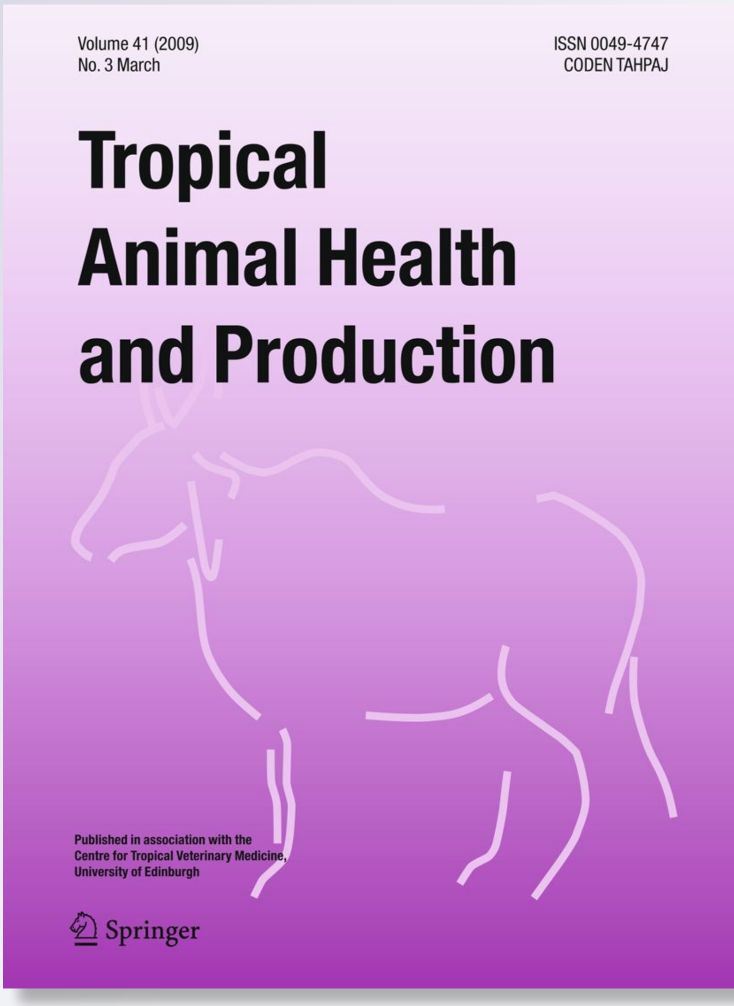

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ORIGINAL RESEARCH

Factors influencing the prevalence of subclinical mastitis in lactating dromedary camels in Riyadh Region, Saudi Arabia

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Abstract The purpose of this study was to determine the prevalence of subclinical mastitis in camels in Riyadh, Saudi Arabia and the factors influencing its incidence. A total of 740 quarter milk samples were collected from 47 camel herds belonging to *Majahim*, *Maghatir*, *Shu'l*, and *Sufer* breeds. California mastitis test (CMT) was used as a screening test for subclinical mastitis. Samples giving negative or trace CMT scores (0) were assigned to healthy quarters, while those giving positive scores of 1+ to 3+ were assigned to subclinically affected quarters. Logistic regression was used to assess the association of breed, parity, and stage of lactation with the prevalence of subclinical mastitis. Milk fat, protein, lactose, solid nonfat percentages and Na, Ca, and K concentrations were compared in CMT-positive versus healthy quarters. One third (33%) of tested quarters had subclinical mastitis based on CMT. The estimated probability of subclinical mastitis with the combined effects of breed, parity, and stage of lactation ranged from 15.8% to 54.6%. The risk of subclinical mastitis increased significantly with parity and with the early stage of lactation. The Shu'l breed had significantly higher prevalence of subclinical mastitis than other breeds. Significant decreases in protein, lactose, and solid nonfat, Ca and K concentrations and increase in Na concentrations were associated with subclinical mastitis. In conclusion, subclinical mastitis is prevalent in Saudi camels, and its incidence is influenced by breed, parity, and stage of lactation.

Keywords Subclinical mastitis · Camels · California mastitis test · Parity · Stage of lactation · Milk composition

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Introduction

The population of dromedary camels (*Camelus dromedarius*) in Saudi Arabia exceeds 800,000 heads. More than one third of these animals is reared in the Central (Riyadh) Region of the country (Agriculture Statistical Year Book 2009). This region occupies an area of about 50,000 km² between latitudes 34–35° N and longitudes 43–46° E. It is situated in a plateau in the center of the Arabian Peninsula where the prevailing climate is typically dry desert climate with irregular and often scanty rain and a long hot summer. During July and August, the average temperature in the region exceeds 43°C. Winters are mild with cold, windy nights. Under such conditions of extreme temperatures, drought, and poor pasture, camels can produce more milk and sustain production for a longer time than any other species of farm animal (Raziq et al. 2008). Because of their unique adaptation to desert conditions, therefore, camels have played and continue to play a major role in the livelihood of the inhabitants of the Arabian Peninsula. Apart from being a major source of meat, certain camel breeds in Saudi Arabia are recognized as dairy camels, with total milk production ranging between 2,500 and 4,900 L per year and primarily reared for that purpose in rural areas and around major cities (Gaili et al. 2000). The animals are usually kept in medium-sized herds, up to about 40 heads each, or larger herds up to 100 heads each (Al-Khamis and Young 2006). Plans are currently underway to establish "modern" camel farms housing several hundred camels for large-scale milk production. This type of camel farming is encouraged to counter land deterioration due to overgrazing and increasing desertification in the region.

The consumption of camel milk is a long-standing tradition in Saudi Arabia and all other parts of the Arabian Peninsula, and the demand for camel milk and other products in the Kingdom and elsewhere is rising. Detailed information regarding milk production in camel-rearing countries is not available. However, the UN Food and Agriculture Organization estimates the global market potential of camel milk to exceed US $10 billion (UNESCO 2007).

Many factors affect milk production and quality, such as breed, age, management, nutrition, parity, and lactation stage. However, in dairy camels, mastitis is the single most important factor affecting production. While clinical mastitis in camels can be easily recognized, subclinical mastitis almost always passes unnoticed, which accounts for its high prevalence among lactating camel herds in many countries (Guliye et al. 2002; Mohammed et al. 2005; Abdel Gadir et al. 2005; 2006; Hawari and Hassawi 2008; Abera et al. 2009). Traditional hand milking, use of anti-suckling devices, presence of teat lesions, and failure to apply basic hygienic measures are important predisposing factors for mastitis in camels (Mohammed et al. 2005; Abdel Gadir et al. 2005).

Few studies have been published on mastitis and milk composition in dromedary camels in Saudi Arabia (Barbour et al. 1985; Hafez et al. 1987), while no information is available regarding the prevalence of subclinical mastitis in these animals and the factors that might influence its prevalence such as breed, type of husbandry, parity, and stage of lactation. Also, no information has been published on changes in milk chemical constituents during subclinical mastitis in these camels. The following study was undertaken to investigate some factors associated with the prevalence of subclinical mastitis in Saudi camels and the effect of the udder health, as determined by California mastitis test (CMT) on camel milk constituents.

Materials and methods

This study was conducted between May 2007 and March 2008. Seven hundred and forty quarter milk samples were collected randomly from 47 camel herds in Riyadh region, Saudi Arabia. Sampled female camels (total 185) belonged to four indigenous breeds that are kept primarily for milk production, namely: *Majahim*, *Maghatir*, *Shu'l*, and *Sufer*. Milk production of different breeds, used in the studied herds, ranged between 4 and 15 kg per day. Sampling was carried out at regular milking time in the morning. All udders were examined for overt signs of mastitis and physical injury, and the milk samples from each quarter were observed for grossly visible abnormalities using a strip cup. Only samples from apparently healthy udders with no visible lesions or changes in milk appearance or consistency were used. Prior to sampling, the udder was washed and dried, teats were disinfected, and the first few streams of milk were discarded. One hundred-milliliter samples were collected from each quarter in sterile universal bottles and transported in ice immediately to the laboratory. Records were kept of the husbandry system, milking procedure and breed, parity (1–≤4), and stage of lactation of each animal. The latter was divided into three stages: stage 1, from the onset to the third month of lactation; stage 2, from >3–6 months of lactation; and stage 3, >6 months of lactation.

California mastitis test (CMT; Bovi-Vet, Kruuse, Germany) was used as an indirect measure of the health status of the udder. Studies in our laboratory have shown a high positive correlation (0.84) between CMT and somatic cell count in camel milk, and both of them were shown to be sensitive and specific in detecting udder infection in these animals (Almutairi 2009, Studies on somatic cell count and some constituents of camel's milk (unpublished MSc thesis, King Saud University)). The usefulness of this test in detecting subclinical mastitis in camels has also been validated by several authors (Younan et al. 2001; Woubit et al. 2001; Abdurahman 2006; Abdel Gader et al. 2006; Hawari and Hassawi 2008; Kathiriya and Shah 2009). In the present study, samples with negative or trace CMT scores (0,t) were assigned to healthy quarters, while those with positive (1+ to 3+) scores were assigned to subclinically affected quarters. Major fat, protein, lactose, and solid nonfat (SNF) percentages were measured using a Lacto Star milk scanner (Funke-Gerber, Labortechnik GmbH, Berlin, Germany). Milk pH was measured using Microprocessor pH Meter (pH 211, Hanna Instruments, Portugal). Ca, Na, and K concentrations were determined using atomic absorption spectrometry (Analyst Spectrophotometer 300, PerkinElmer Inc, Shelton, CT, USA).

Data were divided into two subsets according to CMT scores, healthy quarters (0), and subclinically affected quarters (1+ to 3+). Logistic regression was used to assess factors

Table 1 Number of tested quarters according to breed, type of husbandry, parity, and stage of lactation

Factors		*Majahim*		*Maghatir*		*Shu'l*		*Sufer*		Total	
		No.	%	No.	%	No.	%	No.	%	No.	%
Type of husbandry	Nomadic	70	26.52	8	4.25	54	35.53	60	44.12	192	25.95
	Seminomadic	146	55.30	164	87.23	74	48.68	60	44.12	444	60.00
	Settled	48	18.18	16	8.51	24	15.79	16	11.76	104	14.05
Parity	1	56	21.21	32	17.02	40	26.32	40	29.41	168	22.70
	2	60	22.73	36	19.15	28	18.42	36	26.47	160	21.62
	3	72	27.27	68	36.17	32	21.05	36	26.47	208	28.11
	≥4	76	28.79	52	27.66	52	34.21	24	17.65	204	21.57
Stage of lactation	1	96	36.37	28	14.89	36	23.68	36	26.47	196	26.49
	2	56	21.21	112	59.58	52	34.21	48	35.29	268	36.21
	3	112	42.42	48	25.53	64	42.11	52	38.24	276	37.30
Total quarters		264		188		152		136		740	
Total females		66		47		38		34		185	

Stage 1=onset–3 months of lactation, *stage 2*=>3–6 months of lactation, *stage 3*=>6 months of lactation

associated with the prevalence of subclinical mastitis. The model was as follows:

$$\text{Logit } P(\widehat{X}) = \beta_0 + \alpha_i(X1) + \gamma_j(X2) + \theta_k(X3) + \lambda_1(X4)$$

$i = 1, 2, 3; j = 1, 2, \ldots, 4; k = 1, 2, \ldots, 4; l = 1, 2, 3$
where: β_0, α_i, γ_j, θ_k, and λ_1 were the regression coefficients. $X1$, $X2$, $X3$, and $X4$ were the effects of independent variables of husbandry systems, breed, parity, and stage of lactation, respectively. The effects of udder status on milk constituents were obtained using general linear model procedure in SAS V 8.1 program for Windows, and the means were compared using Duncan's multiple range test.

Results

Although different milking, breeding, and feeding practices were observed, nomadic and seminomadic systems were the most common systems in the studied camel herds. Based on CMT scores, the overall prevalence of subclinical mastitis in these camels was about 33%. Table 1 summarizes the number of quarters tested, and Table 2 summarizes

Table 2 Results of CMT testing according to breed, type of husbandry, parity and stage of lactation

Factors		Healthy quarters		Affected quarters	
		No.	%	No.	%
Type of husbandry	Nomadic	118	61.46	74	38.45
	Seminomadic	316	71.17	128	28.83
	Settled	65	62.50	39	37.50
Breed	*Majahim*	188	71.21	76	28.79
	Maghatir	136	72.34	52	27.66
	Shu'l	80	52.63	72	47.37
	Sufer	95	69.85	41	30.15
Parity	1	124	73.81	44	26.19
	2	114	71.25	46	28.75
	3	147	70.67	61	29.33
	≥4	114	55.88	90	44.12
Stage of lactation	1	118	60.20	78	39.80
	2	194	72.39	74	27.61
	3	186	67.39	90	32.61
Total	499	67.43	241	32.57	

the results of CMT tests according to breed, type of husbandry, parity, and stage of lactation.

Our model showed a significant association of breed, parity, and stage of lactation with the prevalence of subclinical mastitis, while the effect of husbandry system was not significant (Table 3) and, hence, excluded from the model. The estimated probability of subclinical mastitis with the combined effects of breed, parity, and stage of lactation ranged from 15.8% to 54.6%, and the risk of developing subclinical mastitis increased with the number of parities and in the first stage of lactation. Odds ratio (OR) estimates ($\widehat{OR}$) and 95% confidence intervals for the effect of breed, parity, and stage of lactation are given in Table 4. The Shu'l breed had higher probability of subclinical mastitis than the other breeds. The probability of subclinical infection during the fourth parity exceeded that during the first parity by a factor of nearly 2.5 (OR=2.34), while the probability of subclinical mastitis during the fourth parity was nearly double that during the second parity (OR=1.87) and about 1.75 times higher in comparison to the third parity (OR=1.74). The probability of subclinical infection in the first stage of lactation exceeded that during the second and third stage of lactation by 1.82 and 1.35 times (OR=0.55 and 0.74, respectively).

The effects of quarter health status on mean values of milk constituents are shown in Table 5. Only a slight increase in fat percentage was observed, while protein, lactose, and SNF simultaneously decreased by 5.3%, 6.0%, and 5.3%, respectively, with the increase in CMT scores from 0 to 3. On the other hand, significant decreases of 11.4% and 22.5% in Ca and K concentrations, respectively, and a corresponding significant increase of 39.7% in Na concentration were recorded from 0 to 3 CMT scores. Milk pH showed only minor differences between healthy and affected quarters.

Discussion

This is the first study dealing with the prevalence of subclinical mastitis in dromedary camels in Riyadh region and the possible effects of breed, parity, and stage of lactation on the prevalence of mastitis in these animals. Nearly one third of 740 quarter milk samples collected randomly from camel herds in the region was diagnosed with subclinical mastitis based on CMT scores. This high prevalence is comparable to that in many other camel breeding countries and could be related to the fact that in most of these countries camels are reared under nomadic or seminomadic conditions. Such type of husbandry is conducive to a high prevalence of mastitis, presumably because of poor application of basic hygienic standards by nomadic camel herders. On the other hand, the increased prevalence of subclinical mastitis with increasing number of parities in Saudi camels confirms previous observations by Abdel Gadir et al. (2006), while increased prevalence during the first versus later stages of lactation is concordant with observations in cattle and other species of dairy animals (Biffa et al. 2005). According to these authors, the

Table 3 The effect of factors in the logistic model

Factors	*df*	χ^2	*P*
Breed	3	18.78	0.0003
Parity	3	15.81	0.0012
Stage of lactation	2	7.77	0.0205

Table 4 Odd ratios estimates ($\widehat{OR}$) and 95% confidence intervals for the effect of breed, lactation, and stage of lactation

Factors	Comparisons	$\widehat{OR}$	95% CI	
Breed (B)	B1 vs. B2	1.17	0.75	1.82
	B1 vs. B3	2.49	1.62	3.82
	B1 vs. B4	1.28	0.80	2.04
	B2 vs. B3	2.13	1.33	3.42
	B2 vs. B4	1.10	0.66	1.82
	B3 vs. B4	0.52	0.31	0.85
Parity (P)	P1 vs. P2	1.25	0.77	2.05
	P1 vs. P3	1.35	0.84	2.16
	P1 vs. P4	2.34	1.48	3.69
	P2 vs. P3	1.08	0.68	1.71
	P2 vs. P4	1.87	1.19	2.92
	P3 vs. P4	1.74	1.14	2.64
Stage of lactation (S)	S1 vs. S2	0.55	0.36	0.84
	S1 vs. S3	0.74	0.50	1.10
	S2 vs. S3	1.35	0.91	1.99

B1Majahim, *B2 Maghatir*, *B3 Shu'l*, and *B4 Sufer*; *P1–P3* parity 1–3; *S1–S3* stage of lactation 1–3

Table 5 Effects of quarter health status on the means (±SE) of some milk constituents in lactating camels

Milk constituents	Quarter health status	
	Healthy	Subclinical mastitis
Fat (%)	2.91±0.04	3.17±0.06
Protein (%)	3.52±0.02a	3.35±0.03b
Lactose (%)	5.13±0.03a	4.88±0.04b
SNF (%)	9.40±0.05a	8.96±0.08b
Ca (g/100 ml)	96.71±1.01a	87.09±1.51b
Na (g/100 ml)	36.12±0.65a	41.18±1.64b
K (g/100 ml)	90.81±0.05a	77.31±1.91b
pH	6.41±0.01	6.42±0.01

Data in the same row bearing different lowercase letters are significantly different increased prevalence of mastitis with increased parity in dairy animals could be attributed to "the cumulative stress of the mammary tissue from previous pregnancies and lactations" (Boscos et al. 1996), whereas the higher prevalence of subclinical mastitis during the first stage of lactation could be associated with decreased resistance of the mammary gland to infection as a result of immune depression following the stresses and hormonal changes that occur around the time of parturition and onset of lactation (Sordillo 2005; Burvenich et al. 2007).

The higher probability of subclinical mastitis in the Shu'l breed versus other camel breeds could be ascribed to differences in breed susceptibility to udder infection. Differences in susceptibility to mastitis also occur within and among cattle and other dairy animal breeds, which could be partly due to genetic factors (Biffa et al. 2005; Sharma et al. 2006; Ouweltjes et al. 2007).

The decreased concentration of protein, lactose, SNF, Ca, and K and increased concentration of Na during subclinical mastitis in the camels are concordant with findings in cattle, buffaloes, and goats and are probably attributable to decreased synthesis of milk by the inflamed mammary gland (Leitner et al. 2004; Ullah et al. 2005; Batavani et al. 2007). On the other hand, no significant difference in fat percentage was found between healthy and subclinically affected quarters.

It is concluded from this study that subclinical mastitis is prevalent among indigenous dairy camel breeds in Riyadh region, Saudi Arabia; that breed, parity, and stage of lactation influence the prevalence of subclinical mastitis; and that it causes changes in milk composition. Studies into the efficiency of potential control measures should be undertaken along with investigations of the causative bacteria.

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