

Review

Mastitis in camels (*Camelus dromedarius*): Past and recent research in pastoral production system of both East Africa and Middle East

Atif E. Abdelgadir

Department of Preventive Medicine & Public Health, Faculty of Veterinary Medicine, University of Khartoum,
P. O. Box 32, Sudan.

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Udder infection was considered as one of the main constraints for camel rearing. During the last decades the disease has been reported from a number of camels-rearing countries in Africa and Asia such as Egypt, Somalia, Sudan, Kenya, Saudi Arabia, Iraq and United Arab Emirate. An attempt was made in this paper in order to review the status of camel mastitis (*Camelus dromedarius*) research in pastoral production system of both East Africa and Middle East. This paper reviews the forms of mastitis in camel which can be a clinical mastitis (including, acute and chronic mastitis) or sub-clinical mastitis. Clinical mastitis is characterized by hardening and swelling of the udder, pain on palpation and visible alteration of the colour and consistency of milk. Thus, clinical mastitis can be detected by examination of the udder and/or of the milk. While the term sub-clinical mastitis refers to the existence of inflammation in the absence of gross signs and can be detected by indirect tests such as california mastitis test (CMT) and somatic cell count (SCC) as well as microbiological examinations. Furthermore, the major pathogens of camel mastitis are *Staphylococcus aureus*, *Streptococcus agalactiae*, *Bacillus cereus*, *Actinomyces pyogenes*, *Escherichia coli*, *Micrococcus spp.*, and *Corynebacterium bovis*. Regarding the risk factors of camel mastitis, the paper reviews the most important risk factors such as the heavy tick infestation, use of anti-suckling devices, the lesions on udder or teat, and the treatment of infected quarters by cauterization. Moreover, the use of CMT, SCC and bacteriological examinations as diagnostic tools and their values for detection of camel mastitis are also reviewed. Based on the aforementioned, more epidemiological studies on camel mastitis are required in order to have a strong scientific data on the transmission of the disease, characterization of the pathogens causing the disease, other possible risk factors or diagnostic procedures, and the impact of the disease on the public health. Thus, the control strategies can be applied.

Key words: Camel mastitis, pathogens, forms, risk factors, diagnosis.

INTRODUCTION

According to Food and Agriculture Organization (FAO) (1992), consumption of livestock products increases 2 to 3 times more in developing countries as compared to developed countries. This is attributed to the high population growth and an increasing urbanization in the

third world. The FAO report indicated that the food supply must be improved, both in quantity and quality. It is well known that camels play major roles in improving the socio-economic status and survival of the desert dwellers and are major sources of protein and energy for them.

This is due to a number of specific anatomical and physiological characteristics of the camel as well as low susceptibility to diseases (Schwartz and Dioli, 1992).

Schwartz and Dioli (1992) recorded that the camel milk contains the necessary proteins, sugars, fats, minerals and vitamins for the young calves and is a valuable food for the people. Beside that, camel milk is a rich source of vitamin C for the desert people who are unable to get it from other sources. On the other hand, udder infection was considered as one of the main constraints for camel rearing. For instance, it has been noticed in the slaughter houses that early culling of female camel in Iraq was attributed to chronic mastitis and infertility (Al-Ani and Al Shareefi, 1997). During the last decades the disease has been reported from a number of camels-rearing countries in Africa and Asia such as Egypt, Somalia, Sudan, Kenya, Saudi Arabia, Iraq and United Arab Emirate. An attempt was made in this paper in order to review the status of camel mastitis *Camelus dromedarius* research in pastoral production system of both East Africa and Middle East.

STATUS OF CAMEL MASTITIS (*Camelus dromedarius*) RESEARCH IN EAST AFRICA AND MIDDLE EAST

Udder infection of camel

Mastitis is a complex disease occurring worldwide among dairy animals, with heavy economic losses largely due to sub-clinical mastitis. There is extensive literature on bovine mastitis and to some extent on ovine and caprine mastitis. Little is known about camel mastitis. However, cases of mastitis in camel have been reported from different countries, particularly in pastoral production system of East Africa and Middle East and Egypt (Moustafa et al., 1987; Karmy, 1990), Saudi Arabia (Barbour et al., 1985; Hafez et al., 1987; Ramadan et al., 1987; Aljumaah et al., 2011), Iraq (Al-Ani and AlShareefi, 1997), Somalia (Arush et al., 1948; Abdurahman et al., 1992); Sudan (Abdurahman et al., 1995; Suheir et al., 2005), United Arab Emirate (Quandil and Ouadar, 1684), Ethiopia (Almaw and Molla, 2006; Bekele and Molla, 2001; Woubit et al., 2001; Abera et al., 2012) and Kenya (Younan et al., 2001).

PATHOGENS CAUSING CAMEL MASTITIS

Camels under traditional management are usually kept far from urban. Thus, bacteriological examination of the camel milk was considered difficult (Abdurahman et al., 1995). An assumption was made, that the major pathogens

of camel mastitis were *Saphylococcus aureus*, *pyogenes*, *Escherichia coli*, *Micrococcus spp.*, and *Streptococcus agalactiae*, *Bacillus cereus*, *Actinomyces Corynebacterium bovis* (Woubit et al., 2001). Almaw and Molla (2002) and Bekele and Molla (2001) have isolated other *Streptococcus spp.* and coagulase negative Staphylococci from mastitic milk of dromedary camel in pastoral production system of Ethiopia. Furthermore, *E. coli*, *Pseudomonas aeruginosa* and *Klebsiella pneumoniae* have been isolated from both clinical and sub-clinical mastitis (Kapur et al., 1982; Quandil and Ouadar, 1984; El-Jakee, 1998; Bekele and Molla, 2001). On the other hand, relationship between occurrences of camel mastitis and the presence of *Corynebacterium spp.*, *Actinomyces spp.*, and *Bacillus spp.* were reported in Iraq (Al-ani and AlShareefi, 1997), Egypt (El-Jakee, 1998) and Ethiopia (Woubit et al., 2001). Moreover, a research work from Sudan by Suheir et al. (2005) confirmed the presence of *Mycoplasma arginini*, mold and yeast in mastitic milk of she-camel while in Egypt, El-Jakee (1998) stated that camel mastitis caused by anaerobic *Clostridium perfringense* was considered as a problem in the country.

RISK FACTORS OF CAMEL MASTITIS

A study in Sudan by Abdurahman et al. (1995) and Obied et al. (1996) explained that the use of devices to prevent the calves from sucking their dams, together with heavy tick infestation of the udder and the treatment of infected quarters by cauterization have been considered as predisposing factors for camel mastitis (Figures 1 and 2). Furthermore, Bekele and Molla (2001) considered that the heavy tick infestation, use of anti-suck ling devices and the thorny bushes in pastoral areas of Ethiopia might be responsible for udder abnormalities and deformities and blind teats. They also reported a positive relationship between trauma and the occurrence of camel mastitis. Younan et al. (2001) reported that the camel pox might be considered as contributing factor in the spreading of intra-mammary infection caused by *S. agalactiae* in Kenya. Recently, a study from Saudi Arabia by Aljumaah et al. (2001) confirmed that the risk of sub-clinical mastitis of dromedary camel increased significantly with breed, parity and with early stage of lactation. In contrast, Suheir et al. (2005) observed that most of mastitis cases in the camel in Sudan were recorded in the last stages of lactation period and during the fourth and fifth calving. Factors such as Age, production system, hygiene of milking process and presence of lesion on udder/teat were found significantly associated with the prevalence of camel mastitis under different production systems of

E-mail: atifvet@yahoo.com.

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Figure 1. Anti-sucking device (tying of teats).



Figure 2. Tick infestation.



Figure 3. Abscess on the udder.

systems of Pakistan (Ahmed et al., 2012) (Figures 3 and 4).

FORMS OF CAMEL MASTITIS

The forms of mastitis in camel can be clinical mastitis (including, acute and chronic mastitis) or sub-clinical mastitis. Clinical mastitis in camel is characterized by hardening and swelling of the udder, pain on palpation and visible alteration of the colour and consistency of milk. Thus, clinical mastitis can be detected by examination of the udder and/or of the milk (Obied et al., 1996). The term per-acute mastitis refers to severe inflammation, with swelling, heat and pain of the quarter, with a marked systemic reaction that may be fatal. The change in the mammary glands in acute mastitis is similar to those of peracute but the systemic signs are less severe (Quinn et al., 1994; Radostitis et al., 2000). In India, Kapur et al. (1982) recorded a case of peracute mastitis caused by *Klebsiella* spp. and *E. coli* that resulted from contamination during udder surgery while Quandil and Ouadar (1984) reported acute form of camel mastitis.

In Saudi Arabia, Ramadan et al. (1987) described unilateral chronic mastitis caused by *S. aureus* and *Pasteurella haemolytica* in three lactating camels due to obstruction of the teat canals by keratin. He also indicated that the camels with previous history of acute

bacterial mastitis lead to chronic mastitis with subsequent fibrosis and keratinization of the udder tissue (Figure 5). Chronic cases of the camel mastitis due to *S. aureus* have also been reported in Iraq (Al-Ani and Al-Shareefi, 1997). Sub-clinical mastitis was reported in Sudan (Obied et al., 1996; Abdurahman et al., 1995) and Ethiopia (Almaw and Molla, 2000; Bekele and Molla, 2001). The same authors indicated that the term sub-clinical mastitis in camel refers to the existence of inflammation in the absence of gross signs and can be detected by indirect tests such as California mastitis test (CMT) and somatic cell count (SCC), as well as microbiological examinations.

DIAGNOSIS OF CAMEL MASTITIS

Clinical mastitis can be detected by examinations of the udder and/or of the milk, as well as using indirect tests (Obied et al., 1996). Bacteriological examinations of the milk, CMT and SCC have been used as diagnostic tools to detect sub-clinical mastitis in camels (Obied et al., 1996; Abdurahman et al., 1995; Almaw and Molla, 2000; Bekele and Molla, 2001). The value of the CMT for the early detection of mastitis in camel herds was indicated by Moustafa et al. (1987). Moreover, a study on the sensitivity and specificity of CMT in Kenya by Younan et al. (2001) has shown that the CMT can be applied as a

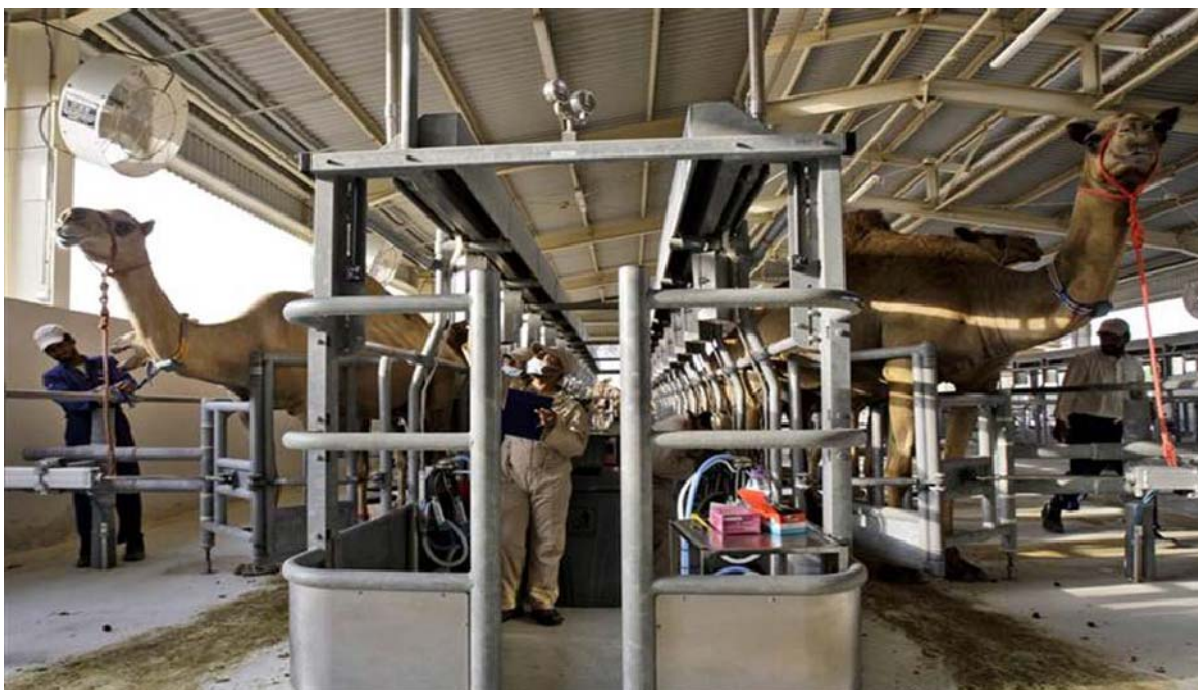


Figure 4. Milking machine.



Figure 5. Chronic mastitis (abscessation and fibrosis of one quarter).

Table 1. Interpretation of the CMT results.

CMT score	Average somatic count (cells per milliliter)	Description of reaction
N (negative)	100,000	No thickening, homogeneous
T (trace)	300,000	Slight thickening. Reaction disappears in 10 s
1 (+)	900,000	Distinct thickening, no gel formation
2 (++)	2,700,000	Thickens immediately, begins to gel, levels in the bottom of cup
3 (+++)	8,100,000	Gel is formed, surface elevates, with a central peak above the mass

**Figure 6.** California mastitis test (CMT). The CMT reagent reacts with the white blood cells and the mixture thickens or gels in proportion to the amount of the infection present.

screening test for the detection of intra-mammary infection with *S. aureus* and *S. agalactiae* in camel. This result supports that of Bekele and Molla (2001) who reported during their study on camel mastitis a positive correlation between CMT scores and bacteriological results. Furthermore, Obied et al. (1996) found a strong correlation between leukocyte counts of camel milk and the CMT scores. An increase of SCC with the degree of CMT and their value in predicting the infection status of the udder in lactating camels has also been reported by Abdurahman (1996) and Al-Ani and Al Shareefi (1997) (Table 1 and Figures 6 and 7).

Variation in the leukocyte counts of colostrums, normal milk and dry period milk from camels have been reported by Moustafa et al. (1987). There were increases in the SCC in camel milk with age, stage and number of lactations, and the results of the CMT, and these were directly correlated with the leukocyte counts (Kospakov, 1976). Abdurahman et al. (1996) in his study of sub-

clinical mastitis in seven lactating bactrian camels (*Camelus bactrianus*) kept at a zoological park in Sweden showed that camels free of udder infection had a higher basal SCC than cows. The author also recorded that the cell fragments may be counted as cells in microscopic counting. Abdurahman et al. (1992) previously recorded the presence of large numbers of the nucleated cell fragments in the camel milk. Similar cell fragments in goat milk did not react with CMT reagent (Schalm et al., 1971).

Some other diagnostic tools have been used for the detection of camel mastitis. For instance, Saad and Thabet (1993) have reported a strong correlation between white side test (WST) and bacteriological result of camel milk samples. Abdurahman et al. (1995) indicated that milk samples from quarters infected with major pathogens higher values for CMT, SCC and adenosine triphosphate (ATP) than samples from quarters that were infected with minor pathogens and from not infected

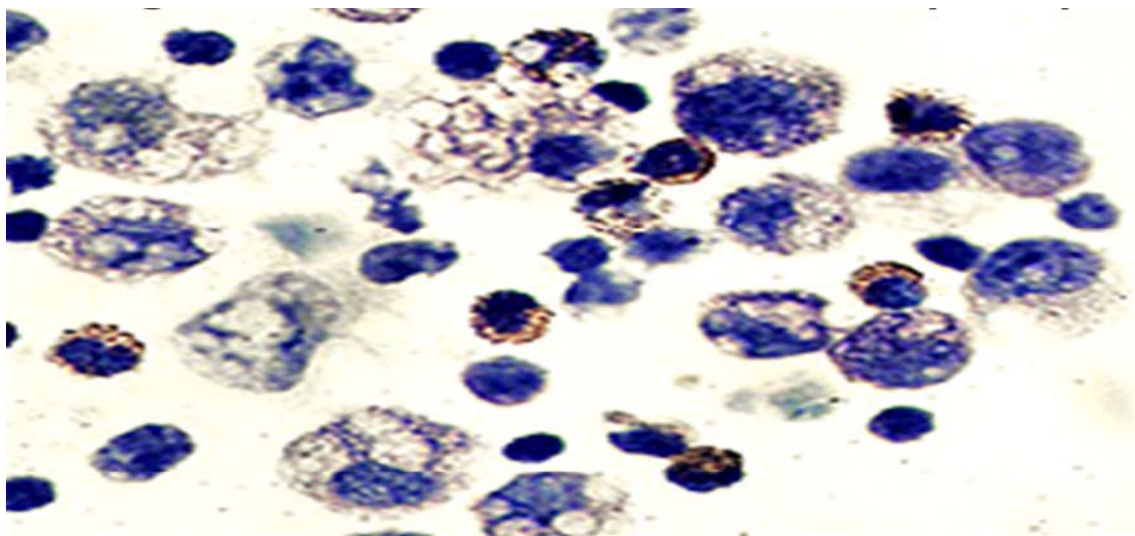


Figure 7. Somatic cell counts (SCC). Cutt-off point (critical point)= over 500,000 to be an indication of udder infection in camels.

quarters. The NAGase test has been used for predicting udder infection in cow. The test is based on measurement of a cell-associated enzyme (N-acetyl- β -D-glucosaminidase) in the milk. A high level of the enzyme indicates a high cell counts (Radostits et al., 2000). In Sudan, Abdurrahman (1995) measured the NAGase activity and concentration of serum albumin from quarter milk samples of lactating camels using both the fluoroscan method and radial immunodiffusion test. The same author indicated that the NAGase was more reliable in predicting bacteriological status of the camel udder than serum albumin. There is a direct relationship between intra-mammary infection in cows and the conductivity of the milk produced. The test is based on the increase in sodium and chloride ions, and the consequent increase in electrical conductivity, which occurs in mastitic milk (Radostits et al., 2000). The milk conductivity was measured for both normal quarter milk samples and intra-mammary infection with *S. aureus* and *S. agalactiae* in lactating camels in Kenya (Younan et al., 2001). The author explained that the conductivity reading was not diagnostic.

CONTROL OF CAMEL MASTITIS

The control of udder infection in camels was mainly based on using antibiotics (intra-mammary infusion). Oxytetracycline, tetracycline, gentamcin, chloramphenicol, pencillin G and kanamycin were effective drugs against major pathogens of camel mastitis. Resistance patterns of some mastitis pathogens of camel against commonly

used anti-microbial agents can be attributed to heavy applications of these anti-microbial agents for the treatment of many infectious diseases for long time (Younan et al., 2001) (Figure 8).

CONCLUSION

Camel mastitis was considered one of the major diseases in pastoral production system of East Africa and Middle East, with a great impact on animal health as well as public health concern. There are two forms of camel mastitis; clinical mastitis which can be detected by inspection of the milk and the udder, the other one being sub-clinical mastitis which can be detected only by indirect tests. California mastitis test (CMT) together with bacteriological examinations have a great value in diagnosis of the disease. Anti-suckling devices, tick infestation, parity, stage of lactation, production system, hygiene conditions and lesions on udder or teat were responsible for spreading of intra-mammary infection in dromedary camel.

RECOMMENDATIONS

1. More epidemiological studies on camel mastitis are required in order to have a strong scientific data on the transmission of the disease, characterization of the pathogens causing the disease, other possible risk factors or diagnostic procedures, and the impact of the disease on the public health. Thus, the control strategies can be



Figure 8. Treatment of camel mastitis with antibiotics (intra mammary infusion).

can be applied.

2. The somatic cell counts (SSC) of the normal and mastitis camel milk needs further investigations.

3. An attempt should be made to increase awareness of camel owners on the importance and impact of udder infection on public health and milk yield.

4. In order to control and prevent mastitis in camels, it will be valuable to avoid risk factors of camel mastitis such as use of anti-suckling devices, tick infestation and udder lesions.

5. Monitoring of zoonotic diseases such as salmonellosis, brucellosis and tuberculosis in the camel milk herds in pastoral production system of East Africa and Middle East is required.

Conflict of Interest

The author(s) have not declared any conflict of interests.

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