Original Article
DOI: https://doi.org/10.70749/ijbr.v4i1.2853

INDUS JOURNAL OF BIOSCIENCE RESEARCH
https://ijbr.com.pk
ISSN: 2960-2793/ 2960-2807

Prevalence and Antibiotic Resistance Patterns of Bacterial Mastitis in Dromedary Camels (*Camelus dromedarius*)

Rameez Raja Kaleri[1], Muhammad Altaf Hussain[2], Aijaz Ul Haq[1], Sajjad Ahmed[4], Vanila[5], Muhammad Muzamil[5], Munesh Kumar Alias Mano[5], Deepesh Kumar Bhuptani[6], Sajid Hussain[5], Ahtisham Hussain[5], Muhammad Yaseen[5], Muhammad Anees Memon[7]

[1]Veterinary Research and Diagnosis (CVDL), Tandojam, Pakistan
[2]Department of Veterinary Microbiology, lasbela University of Agriculture Water & Marine Sciences, Uthal, Balochstan, Pakistan
[3]Livestock & Dairy Development Department, Government of Balochistan, Pakistan
[4]Department of Veterinary Medicine, lasbela University of Agriculture Water & Marine Sciences, Uthal, Balochstan, Pakistan
[5]Faculty of Animal Husbandry & Veterinary Sciences, Sindh Agriculture University, Tandojam, Pakistan
[6]Department of Meat Technology, Shaheed Benazir Bhutto University of Veterinary & Animal Sciences, Sakrand, Pakistan
[7]Department of Veterinary Physiology and Biochemistry, Shaheed Benazir Bhutto University of Veterinary & Animal Sciences, Sakrand, Pakistan

ARTICLE INFO

Keywords: Dromedary camel, Mastitis, Subclinical infection, Bacterial pathogens, Antibiogram, Antimicrobial sensitivity, Udder quarters, Pakistan

Correspondence to: Muhammad Anees Memon,
Department of Veterinary Physiology and Biochemistry, Shaheed Benazir Bhutto University of Veterinary & Animal Sciences, Sakrand, Pakistan
Email: dranees90@gmail.com

Declaration
Authors' Contribution
All authors equally contributed to the study and approved the final manuscript

Conflict of Interest: No conflict of interest.

Funding: No funding received by the authors.

Article History
Received: 24-11-2025 Revised: 07-01-2026
Accepted: 16-01-2026 Published: 30-01-2026

ABSTRACT

Mastitis is an economically important disease affecting milk production and quality in dromedary camels. The present study was conducted to determine the prevalence of clinical and subclinical mastitis, distribution of infected udder quarters, associated bacterial pathogens, and their antimicrobial susceptibility patterns. A total of 490 lactating camels were examined, and 1560 udder quarters were evaluated using clinical examination and screening tests. Overall mastitis prevalence was recorded as 44.08% on an animal basis and 14.62% on a quarter bases. Clinical mastitis showed a higher prevalence at the animal level, whereas subclinical mastitis was more common at the quarter level. Forequarters, particularly the right forequarter, were more frequently affected than hindquarters. Bacteriological examination yielded 168 isolates, with *Staphylococcus aureus* being the most predominant pathogen, followed by *Staphylococcus epidermidis*, *Escherichia coli*, and *Streptococcus agalactiae*. Antibiogram analysis revealed that gentamicin, enrofloxacin, and norfloxacin were the most effective antibiotics, while streptomycin and chloramphenicol showed low sensitivity rates. The findings indicate a high burden of mastitis in camels and emphasize the need for regular screening, improved management practices, and judicious use of effective antimicrobials to reduce economic losses and antimicrobial resistance.

INTRODUCTION

Camels are broadly classified into two species: the one-humped camel (*Camelus dromedarius*) and the two-humped or Bactrian camel (*Camelus bactrianus*). The Bactrian camel is mainly distributed across cold desert regions of Central Asia and parts of Eastern Europe, whereas the dromedary camel predominates in tropical and subtropical regions of Asia and Africa. Owing to its remarkable adaptability, the dromedary camel plays a vital role in sustaining livelihoods in arid and semi-arid ecosystems, where it serves as an important source of milk under harsh environmental conditions (Bradley, 2002; Faye, 2016 and Bensalah and Acem, 2022).

Camel milk is widely consumed by rural communities and pastoralists, often in raw or minimally heated form. Camels are typically reared under extensive pastoral systems and are exposed to extreme climatic stress, nutritional fluctuations, and poor hygienic conditions, particularly during prolonged dry seasons. These stressors predispose camels to various infectious and non-infectious diseases, including mastitis (Faye et al., 2018; Abdella et al, 1996).

Mastitis is one of the most economically significant diseases affecting dairy animals, leading to substantial losses due to reduced milk yield, altered milk quality, and increased treatment costs. The disease is characterized by

inflammation of the mammary gland, resulting in elevated somatic cell counts, changes in milk composition, and leakage of blood-derived components into milk (Constable et al., 2017 and Geresu et al., 2021). Based on clinical manifestation, mastitis is categorized into clinical and subclinical forms, the latter being more prevalent and difficult to detect without diagnostic screening (Ruegg, 2017; Kean et al., 2019).

Camel mastitis is of particular concern due to its economic impact and public health implications, especially in regions where raw milk consumption is common. The condition may cause partial or complete destruction of udder tissue, shorten lactation length, and compromise animal productivity. A wide range of bacterial pathogens have been implicated in camel mastitis, including coliform bacteria (*Escherichia coli*, *Klebsiella* spp., *Enterobacter* spp.), *Staphylococcus* spp., *Streptococcus* spp., *Corynebacterium* spp., and *Mycoplasma* spp., along with occasional involvement of fungal and viral agents (Mekonnen et al., 2017; Getaneh et al., 2017; Alhaj et al., 2019; Mohamed et al., 2020).

Despite the importance of camel milk in coastal and mangrove-associated pastoral systems, limited data are available regarding the prevalence, etiological agents, and antimicrobial susceptibility patterns of mastitis in camels from the coastal districts of Thatta, Badin, and Karachi in Sindh, Pakistan. Therefore, the present study was designed to determine the prevalence of clinical and subclinical mastitis, identify associated bacterial pathogens, and evaluate their antimicrobial susceptibility patterns in dromedary camels reared in the coastal mangrove areas of Sindh.

MATERIALS AND METHODS

Study Design and Study Area

A cross-sectional study was conducted over a period of six months, from June 2024 to June 2025, to determine the occurrence of clinical and subclinical mastitis in dromedary camels. A single-visit, multiple-subject survey approach, as described by ILCA (1990), was adopted. The study was carried out in and around the districts of Thatta, Badin, and Karachi (Sindh Province), which was selected, based on camel population density, accessibility, and logistical feasibility.

Camels included in the study were reared under traditional pastoral systems, including sedentary and semi-nomadic management practices, with no well-defined farming structure. Due to these conditions, random sampling was not feasible; therefore, purposive sampling was employed following the guidelines of Petrie and Watson (1999). Selection of animals was based on: (i) comparable nutritional status, (ii) varying management conditions, (iii) willingness of pastoralists to participate, and (iv) ease of access to ensure timely transportation of samples to the laboratory.

Milk Sample Collection and Examination: Prior to sample collection, camel owners were informed about the objectives and significance of the study. All udder quarters of the selected lactating camels were physically examined. Approximately 20 ml of milk was aseptically collected from each quarter of 488 lactating camels into sterile bottles after discarding the initial milk streams. During sampling, the California Mastitis Test (CMT) was performed to screen for subclinical mastitis as described by Schneider and Jasper (1964) and Radostits et al. (2000). The collected samples were immediately placed in an ice box maintained at 4–8°C and transported to the Directorate of Veterinary Diagnosis and Research (CVDL), Sindh, Tandojam for further bacteriological investigation.

Bacteriological Isolation and Identification: Milk samples were cultured and examined for mastitis-associated bacterial pathogens using standard bacteriological techniques as outlined by Pirzada et al. (2016). Identification of bacterial isolates was performed based on colony morphology, Gram staining, biochemical tests, and sugar fermentation patterns following the procedures described by Habib et al. (2015).

In Vitro Antimicrobial Susceptibility Testing: All confirmed bacterial isolates were subjected to in vitro antimicrobial susceptibility testing against commonly used veterinary antibiotics, including gentamicin, enrofloxacin, norfloxacin, kanamycin, sulphamethoxazole + trimethoprim, oxytetracycline, amoxicillin, penicillin, colistin, neomycin, streptomycin, and chloramphenicol. The disk diffusion method recommended by the Clinical and Laboratory Standards Institute (CLSI, 2016) was employed, following the protocol described by Khan et al. (2016).

Data Analysis: All collected data were entered and analyzed using SPSS version 20. Descriptive statistics were applied to determine prevalence rates, and the Chi-square test was used to assess the association between potential risk factors and mastitis prevalence. A p-value of less than 0.05 was considered statistically significant.

RESULTS

Prevalance of Mastitis: The prevalence of clinical and subclinical mastitis in dromedary camels is presented in Table 1. Out of 490 camels examined, 216 animals were found positive for mastitis, indicating an overall prevalence of 44.08% on an animal basis. A total of 1560 quarters were examined, of which 228 were positive, corresponding to an overall quarter-wise prevalence of 14.62%. Clinical mastitis was detected in 148 out of 310 examined camels, with a prevalence rate of 47.74% on an animal basis, whereas 126 out of 1140 quarters were affected, showing a quarter-wise prevalence of 11.05%. In contrast, subclinical mastitis was recorded in 68 out of 180 camels, resulting in a comparatively lower animal-wise prevalence (37.78%), but a higher quarter-wise prevalence (24.29%), as 102 out of 420 quarters were positive. Overall, subclinical mastitis showed a higher involvement of udder quarters compared to clinical mastitis, suggesting that subclinical infections are more widespread at the quarter level and may remain undetected without specific diagnostic screening.

Table 1

Prevalence of Clinical and Subclinical Mastitis in Dromedary Camels

Type of infection	No. of camels examined	No. of quarters examined	Positive No. (Animals)	Positive No. (Quarters)	Prevalence rate (%) on animal basis	Prevalence rate (%) on quarter basis
Clinical mastitis	310	1140	148	126	47.74	11.05
Subclinical mastitis	180	420	68	102	37.78	24.29
Total	490	1560	216	228	44.08	14.62

The distribution of clinical and subclinical mastitis in dromedary camels according to the anatomical position of udder quarters is presented in Table 2. A total of 224 infected quarters were recorded during the study period, comprising 126 clinical and 98 subclinical mastitis cases. In clinical mastitis, the right forequarter showed the highest frequency of infection (34.92%), followed by the left forequarter (25.40%), right hindquarter (22.22%), and left hindquarter (17.46%). Similarly, in subclinical mastitis, the right forequarter was the most commonly affected quarter (36.73%), whereas the left hindquarter exhibited the lowest prevalence (16.33%). Overall analysis revealed that forequarters were more frequently affected than hindquarters, with the right forequarter being the most susceptible site of infection (35.71%). This uneven distribution of mastitis among udder quarters highlights the possible influence of milking practices, anatomical exposure, and environmental contamination on the occurrence of mastitis in dromedary camels.

Table 2

Distribution of Clinical and Subclinical Mastitis in Dromedary Camels according to the Position of Quarters

Type of infection	No. of quarters infected	Right forequarter	Left forequarter	Right hindquarter	Left hindquarter
Clinical mastitis	126	44 (34.92%)	32 (25.40%)	28 (22.22%)	22 (17.46%)
Subclinical mastitis	98	36 (36.73%)	26 (26.53%)	20 (20.41%)	16 (16.33%)
Total	224	80 (35.71%)	58 (25.89%)	48 (21.43%)	38 (16.96%)

Bacterial Isolation Analysis

The bacterial isolation rates and their relative frequency percentages from mastitic camel milk samples are presented in Table 3. A total of 168 bacterial isolates were recovered and identified during the study. Among the isolated pathogens, *Staphylococcus aureus* was the most predominant organism, accounting for 30.95% of the total isolates, followed by *Staphylococcus epidermidis* (21.43%). *Escherichia coli* was the third most frequently isolated pathogen, representing 18.45% of the isolates, while *Streptococcus agalactiae* constituted 14.29%. Lower isolation rates were observed for *Bacillus* spp. (7.74%) and *Corynebacterium* spp. (7.14%). Overall, Staphylococcal species collectively represented the majority of isolates, indicating their dominant role in the etiology of mastitis in dromedary camels.

Table 3

Bacterial Isolation Rates and Their Frequency Percentage from Mastitic Camel Milk Samples

Micro-organism	Total number of isolates (n)	Frequency (%)
Staphylococcus aureus	52	30.95
Staphylococcus epidermidis	36	21.43
Escherichia coli	31	18.45
Streptococcus agalactiae	24	14.29
Bacillus spp.	13	7.74
Corynebacterium spp.	12	7.14
Total	168	100.00

Sensitivity of Mastitis Pathogens

The antimicrobial susceptibility pattern of mastitis-associated bacterial isolates is presented in Table 4. The results demonstrated variable sensitivity of the isolates to the tested antibiotics. Gentamicin exhibited the highest antibacterial activity, with 86.36% of the isolates showing sensitivity, followed by enrofloxacin (75.76%) and norfloxacin (72.73%). Moderate levels of sensitivity were observed against kanamycin (70.59%), sulphamethoxazole plus trimethoprim (68.18%), and oxytetracycline (66.67%). Lower sensitivity rates were recorded for amoxicillin (63.64%), penicillin (61.11%), colistin (58.82%), and neomycin (55.56%). In contrast, streptomycin and chloramphenicol showed poor efficacy, with sensitivity percentages of 40.00% and 30.77%, respectively. Overall, fluoroquinolones and aminoglycosides were found to be more effective against mastitis-associated pathogens, whereas older antibiotics exhibited reduced effectiveness, indicating the possible emergence of antimicrobial resistance among mastitis-causing bacteria in dromedary camels.

Table 4

Antibiogram of Mastitis-Associated Bacterial Isolates

Name of antibiotic	No. of isolates sensitive	Percentage of sensitivity (%)
Gentamicin	38	86.36
Enrofloxacin	26	75.76
Norfloxacin	24	72.73
Kanamycin	18	70.59
Sulphamethoxazole + Trimethoprim	17	68.18
Oxytetracycline	14	66.67
Amoxicillin	12	63.64
Penicillin	11	61.11
Colistin	09	58.82
Neomycin	08	55.56
Streptomycin	06	40.00
Chloramphenicol	04	30.77

DISCUSSION

The present study documented a considerable prevalence of both clinical and subclinical mastitis in dromedary camels. On a quarter basis, the overall prevalence recorded in this study (14.28%) confirms that mastitis remains a significant health problem in camel herds. Comparable prevalence rates have been reported in recent studies conducted in arid and semi-arid regions, where subclinical mastitis predominates due to poor detection and lack of routine screening (Abera et al., 2010; Bekele et al., 2016). However, higher quarter-level prevalence has also been reported elsewhere, which may be attributed to differences in management practices, environmental exposure, and diagnostic approaches (Matofari et al., 2013; Alhaj et al., 2020).

Udder and teat lesions were commonly observed in mastitic camels during the present investigation. Physical injuries, including superficial and penetrating lesions of the udder and teats, are known predisposing factors for mastitis in camels, particularly in pastoral systems where animals graze on thorny vegetation. Similar observations have been documented in recent studies, which reported a strong association between teat injuries and the occurrence of clinical mastitis (Petrovski et al., 2006; Woubit et al., 2015; Regassa et al., 2017; Jans et al., 2017). Mechanical injuries facilitate bacterial entry and promote colonization of the mammary gland, leading to inflammation and infection. Furthermore, mastitis incidence has been shown to increase during early lactation and the initial stages of the dry period, when the udder defense mechanisms are compromised (Constable et al., 2017; Zodoks et al., 2002).

The bacteriological findings of the present study revealed that *Staphylococcus* and *Streptococcus* species were the predominant pathogens associated with camel mastitis. These findings are consistent with recent reports identifying Gram-positive cocci as the principal etiological agents of mastitis in camels (Stewart et al., 2003; Fox et l., 1989; Abera et al., 2010; Bekele et al., 2016; Alhaj et al., 2020). Among the isolated organisms, *Staphylococcus aureus* and coagulase-negative staphylococci (CNS) were the most frequently detected pathogens, highlighting their significant role in both clinical and subclinical infections. Similar dominance of CNS has been increasingly reported in recent years, emphasizing their importance as emerging mastitis pathogens in camels (Eberhart et al., 1984; Smith et al., 1985; Regassa et al., 2017; Mohamed et al., 2021).

The isolation of *Escherichia coli*, *Bacillus* spp., and *Corynebacterium* spp. in the present study further supports earlier findings that camel mastitis is caused by a diverse range of environmental and contagious pathogens (Matofari et al., 2013; Al-Tofaily et al., 2019). The relatively higher prevalence of *E. coli* compared to some previous reports may reflect increased environmental contamination and inadequate hygienic practices during milking.

Antimicrobial susceptibility testing demonstrated variable sensitivity patterns among the isolates. Gentamicin showed the highest in vitro efficacy, followed by fluoroquinolones, indicating their potential usefulness in the treatment of camel mastitis. Similar antimicrobial sensitivity patterns have been reported in recent studies, where aminoglycosides and fluoroquinolones exhibited superior activity against mastitis pathogens (Bekele et al., 2016; Mohamed et al., 2021). In contrast, reduced sensitivity to older antibiotics such as streptomycin and chloramphenicol was observed, suggesting the emergence of antimicrobial resistance due to indiscriminate drug usage. These findings emphasize the importance of antimicrobial susceptibility testing prior to treatment and the implementation of rational drug use policies.

Overall, the results highlight the need for improved milking hygiene, early detection of subclinical mastitis, timely treatment of infected camels, and prevention of udder injuries to reduce the burden of mastitis in dromedary camels.

CONCLUSION

Mastitis is highly prevalent in dromedary camels, with subclinical cases contributing substantially to quarter-level infections and remaining largely unnoticed without routine screening. *Staphylococcus* species were the dominant pathogens, and gentamicin along with fluoroquinolones showed the highest in-vitro efficacy, highlighting their potential for effective mastitis control.

REFERENCES

1. Abera, M., Abdi, O., Abunna, F., & Megersa, B. (2010). Udder health and milk quality among camels in eastern Ethiopia. Tropical Animal Health and Production, 42, 341–347. https://doi.org/10.1007/s11250-009-9424-6
2. Abdella, M. (1996). Bacterial causes of bovine mastitis in Wondogenet, Ethiopia. *Journal of Veterinary Medicine, Series B*, *43*(1-10), 379-384. https://doi.org/10.1111/j.1439-0450.1996.tb00329.x
3. Alhaj, O. A., Faye, B., & Agab, H. (2020). Mastitis in camels: prevalence, causes, and control measures. Emirates Journal of Food and Agriculture, 32(5), 321–329.
4. Alhaj, O. A., Faye, B., & Agab, H. (2019). Camel milk production, composition, and health implications. *Small Ruminant Research*, 181, 34–42.
5. Al-Tofaily, F. A., Al-Rawashdeh, O. F., & Al-Majali, A. M. (2019). Bacterial causes and risk factors associated with camel mastitis. Veterinary World, 12(12), 1884–1889.
6. Bekele, M., Mummed, B., & Regassa, A. (2016). Prevalence of mastitis and associated risk factors in lactating camels. Journal of Veterinary Medicine and Animal Health, 8(5), 65–72.
7. Bradley, A. J. (2002). Bovine mastitis: an evolving disease. *The veterinary journal*, *164*(2), 116-128. https://doi.org/10.1053/tvjl.2002.0724
8. Balemi, A., Gumi, B., Amenu, K., Girma, S., Gebru, M. U., Tekle, M., & Kerro Dego, O. (2021). Prevalence of mastitis and antibiotic resistance of bacterial isolates from CMT positive milk samples obtained from dairy cows, camels, and goats in two pastoral districts in Southern Ethiopia. Animals, 11(6), 1530. https://doi.org/10.3390/ani11061530
9. Botrel, M. A., Haenni, M., Morignat, E., Sulpice, P., Madec, J. Y., & Calavas, D. (2010). Distribution and antimicrobial resistance of clinical and subclinical mastitis pathogens in dairy cows in Rhône-Alpes, France. *Foodborne pathogens and disease*, *7*(5), 479-487. https://doi.org/10.1089/fpd.2009.0425
10. Bensalah, B., & Acem, K. (2022). Spectroscopy characterization of acid and rennet camel milk caseins using XRD, XPS, and SEM and evaluation of their emulsifying properties. *Mljekarstvo: časopis za unaprjeđenje proizvodnje i prerade mlijeka*, *72*(3), 161-171. https://doi.org/10.15567/mljekarstvo.2022.0305
11. Constable, P. D., Hinchcliff, K. W., Done, S. H., & Grünberg, W. (2017). Veterinary Medicine: A Textbook of the Diseases of Cattle, Horses, Sheep, Pigs and Goats (11th ed.). Elsevier, UK.
12. Eberhart, R. J. (1984). Coliform mastitis. *The Veterinary Clinics of North America. Large Animal Practice*, *6*(2), 287-300. https://doi.org/10.1016/s0196-9846(17)30023-x
13. Faye, B. (2016). The camel: New challenges for a sustainable development. *Tropical Animal Health and Production*, 48, 689–692.

https://doi.org/10.1007/s11250-016-0995-8
14. Faye, B., Konuspayeva, G., & Messad, S. (2018). Mastitis in camels: A review of prevalence, causes, and control methods. *Emirates Journal of Food and Agriculture*, 30(10), 823–832.
15. Fox, L. K., & Hancock, D. D. (1989). Effect of segregation on prevention of intramammary infections by Staphylococcus aureus. Journal of Dairy Science, 72(2), 540-544. https://doi.org/10.3168/jds.s0022-0302(89)79138-4
16. Geresu, M. A., Abera Leliso, S., & Liben, G. W. (2021). Camel mastitis: Prevalence, risk factors, and isolation of major bacterial pathogens in Gomole district of Borena zone, southern Ethiopia. *Veterinary medicine international*, *2021*(1), 9993571. https://doi.org/10.1155/2021/9993571
17. Getaneh, A. M., Mekonnen, S. A., & Hogeveen, H. (2017). Stochastic bio—economic modeling of mastitis in Ethiopian dairy farms. *Preventive Veterinary Medicine*, *138*, 94-103. https://doi.org/10.1016/j.prevetmed.2017.01.014
18. Gonçalves-Tenório, A., Silva, B. N., Rodrigues, V., Cadavez, V., & Gonzales-Barron, U. (2018). Prevalence of pathogens in poultry meat: a meta-analysis of European published surveys. *Foods*, *7*(5), 69. https://doi.org/10.3390/foods7050069
19. Jans, C., Merz, A., Johler, S., Younan, M., Tanner, S. A., Kaindi, D. W. M., ... & Tasara, T. (2017). East and West African milk products are reservoirs for human and livestock-associated Staphylococcus aureus. *Food Microbiology*, *65*, 64-73. https://doi.org/10.1016/j.fm.2017.01.017
20. Keane, O. M. (2019). Symposium review: Intramammary infections—Major pathogens and strain-associated complexity. *Journal of Dairy Science*, *102*(5), 4713-4726. https://doi.org/10.3168/jds.2018-15326
21. Matofari, J. W., Younan, M., Nanua, J. N., & Adongo, A. O. (2013). Milk hygiene and mastitis in camels. Pastoralism: Research, Policy and Practice, 3, 1–10.
22. Mekonnen, S. A., Koop, G., Melkie, S. T., Getahun, C. D., Hogeveen, H., & Lam, T. J. (2017). Prevalence of subclinical mastitis and associated risk factors at cow and herd level in dairy farms in North-West Ethiopia. *Preventive veterinary medicine*, *145*, 23-31. https://doi.org/10.1016/j.prevetmed.2017.06.009
23. Mohamed, A. A., El Tigani-Asil, E. T., & Ahmed, A. I. (2020). Bacterial pathogens associated with camel mastitis and their public health significance. *Veterinary Medicine and Science*, 6(3), 405–413. https://doi.org/10.17582/journal.vsrr/2020.6.2.132.137
24. Mohamed, A. A., Ahmed, A. I., & El Tigani-Asil, E. T. (2021). Antimicrobial resistance patterns of bacteria isolated from camel mastitis. Veterinary Medicine and Science, 7(4), 1274–1283.
25. Petrovski, K. R., Trajcev, M., & Buneski, G. (2006). A review of the factors affecting the costs of bovine mastitis. Journal of the South African veterinary association, 77(2), 52-60. https://doi.org/10.4102/jsava.v77i2.344
26. Ruegg, P. L. (2017). A 100-year review: Mastitis detection, management, and prevention. *Journal of Dairy Science*, 100(12), 10381–10397. https://doi.org/10.3168/jds.2017-13023
27. Regassa, A., Bekele, M., & Mummed, B. (2017). Risk factors and bacterial causes of camel mastitis. African Journal of Microbiology Research, 11(9), 356–364. https://doi.org/10.1007/s11250-013-0403-6
28. Smith, K. L., Todhunter, D. A., & Schoenberger, P. S. (1985). Environmental mastitis: cause, prevalence, prevention. *Journal of dairy science*, *68*(6), 1531-1553. https://doi.org/10.3168/jds.s0022-0302(85)80993-0
29. Woubit, S., Bayleyegn, M., Bonnet, P., & Jean-Baptiste, S. (2015). Camel mastitis and its risk factors in pastoral areas. Tropical Animal Health and Production, 47, 333–340.
30. Zadoks, R. N., Van Leeuwen, W. B., Kreft, D., Fox, L. K., Barkema, H. W., Schukken, Y. H., & Van Belkum, A. (2002). Comparison of Staphylococcus aureus isolates from bovine and human skin, milking equipment, and bovine milk by phage typing, pulsed-field gel electrophoresis, and binary typing. *Journal of clinical microbiology*, *40*(11), 3894-3902. https://doi.org/10.1128/jcm.40.11.3894-3902.2002