ISSN 0971-6777 (Print)
ISSN 2277-8934 (Online)

JOURNAL OF CAMEL PRACTICE AND RESEARCH

www.camelsandcamelids.com • www.indianjournals.com

Volume 31 April 2024 Number 1

In This Issue

Transformative technologies for the future of camel

Artificial intelligence for improved diagnostics, therapeutics and health outcomes

Camel lameness- diagnostic imaging in diagnosis

Lactation related haematological changes - camels reared under semi-intensive farming system

Camel milk- factors influencing the physicochemical and mineral composition of

Paralysis caused by *Hyalomma dromedarii*

Nocardiosis

Microanatomical studies on the spleen's capsule

KRTAP7 gene for hair quality- molecular characterisation

Raw camel milk and milk powder

Isolation and antimicrobial resistance of *Escherichia coli*- camel milk and powder

Mandibular fracture using external skeletal fixation

Existing managemental practices of camel farmers

Aquaporin1 in the vas deferens and prostate gland

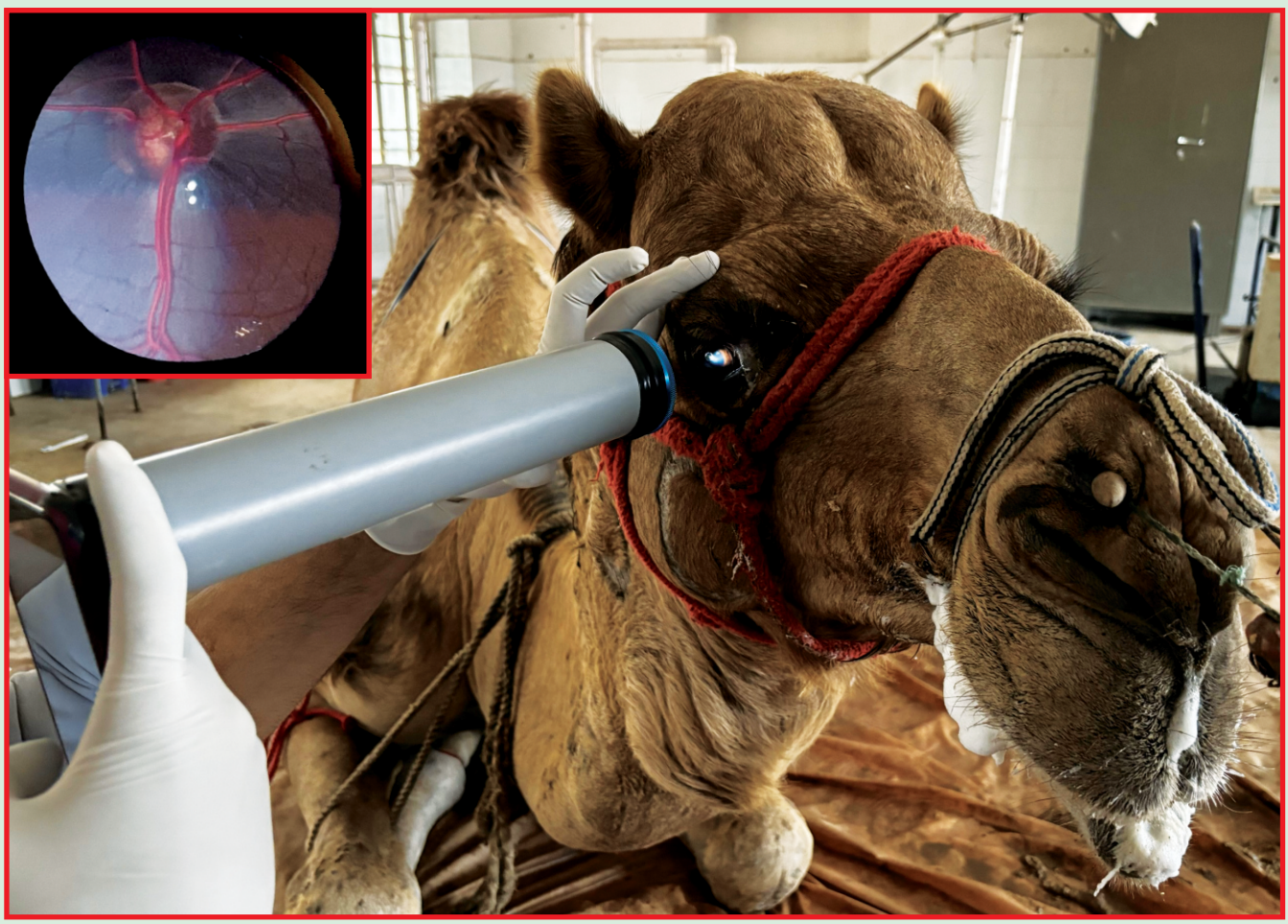
Physico-chemical properties of buffalo, camel and blended milk

Smartphone fundus imaging

Dermoid cyst- effect of gender and age

Nail avulsion

Lipomas giant subcutaneous



JOURNAL OF CAMEL PRACTICE AND RESEARCH

CAMEL PUBLISHING HOUSE
Bikaner - 334001, INDIA

Manuscripts and other related correspondence may be made to :

Dr. Tarun Kumar Gahlot
Editor, Journal of Camel Practice and Research
67, Gandhi Nagar West
Near Lalgarh Palace
Bikaner-334001, INDIA

Mobile : 0091-9414137029
Email : tkcamelvet@yahoo.com
Website : www.camelsandcamelids.com • www.tkgahlotcamelvet.com • www.indianjournals.com

Scope of Journal of Camel Practice and Research

Journal of Camel Practice and Research (JCPR) publishes only research and clinical manuscripts related to the Camelids (Old and New World camelids), hence published contents are consistent with the title and scope of the journal. Review articles on emerging research are invited and published. JCPR also publishes the news related to the New or Old World Camelids, specially those related to new products, conferences, books, trainings or workshops etc.

SUBSCRIPTION RATE - 2024

ANNUAL Rs. 4500/- or US $ 450

Note : *Subscription in Rupees is applicable to Indian subscribers only.*

Publisher : The **Journal of Camel Practice and Research** (Triannual) is published by the **"Camel Publishing House"** 67, Gandhi Nagar West, Near Lalgarh Palace, Bikaner-334001, India. email: tkcamelvet@yahoo.com

Cover Design: Tarun Kumar Gahlot

Cover Photo: Fundus image capturing using smart phone fundus imaging assembly

Courtesy: Bharat Bandhu and S.K. Jhirwal, Bikaner, India

Printer: Sankhla Printers, Vinayak Shikhar, Near Polytechnic College, Bikaner-334003, India.

Phone: 0091 - 151 - 2242023

CONTENTS

Volume 31 **April 2024** **Number 1**

S.No.	Title of Contents and Authors	Page No.
1.	Transformative technologies for the future of camel welfare: artificial intelligence for improved diagnostics, therapeutics and health outcomes Ahmed Alsaleem, Saad Shousha, Mohamed Marzok, Sheryar Afzal, Ahmed Alameen, Ibrahim Albokhadaim and Mahmoud Kandeel	1-9
2.	Role of diagnostic imaging in diagnosis of camel lameness: current status and future prospectives Marwa H. Hassan and Ashraf M. Abu-Seida	11-16
3.	Factors influencing the physicochemical and mineral composition of camel milk in eastern Algeria Meroua Kraimia, Abdelkader Adamou, Saliha Boudjenah-Haroun and Mohammed Hocine Benaissa	17-24
4.	Lactation related changes of haematological parameters of female dromedary camels reared under semi-intensive farming system in Algerian extreme arid region Maria Chikha, Tarek Khenenou, Djalel Eddine Gherissi, Rabah Mayouf, Djallal Eddine Rahmoun, Naif Al-Gabri, Nacira Ramdani, Anas Ayyad Abu-Sulik, Hafiza Aidoudi and Sabry Mohamed El-Bahr	25-28
5.	Nocardiosis in a dromedary camel-case report Fatma Al Mheiri, Marina Joseph, Jörg Kinne, Sunitha Joseph, Shantymol V Jose and Ulrich Wernery	29-32
6.	Paralysis of a dromedary camel caused by *Hyalomma dromedarii* infestation U. Wernery, C. Hebel, F.G. Al Mheiri, R.K. Schuster and J. Kinne	33-34
7.	Localisation of aquaporin1 in the vas deferens and prostate gland of the dromedary camel (*Camelus dromedarius*) during rutting and non-rutting season Abdelrahman M. A. Elseory	35-42
8.	Microanatomical studies on the spleen's capsule in one humped camel (*Camelus dromedarius*) Ashok Dangi, Pankaj Kumar Thanvi and Raj Kumar	43-47
9.	Existing managemental practices of camel farmers in semi-arid region of Rajasthan Santosh Kumar Rao, Navav Singh, Sanjita Sharma, Poonam Lata, Ashok Baindha Vipin Chandra and Govind Singh Dhakad	49-55
10.	Molecular characterisation of keratin-associated protein-7 (*KRTAP7*) gene for hair quality in Indian Dromedary camel Nistha Yadav, Urmila Pannu, Basanti Jyotsana, Ved Prakash, Sagar A. Khulape, Ajay Kumar, Gayatri Gujar and Manju Nehara	57-63
11.	Isolation and antimicrobial resistance profile of *Escherichia coli* in raw camel milk and camel milk powder Amita, Deepika Dhuria, Manohar Sain, Yogesh Kumar, Vaishali and Devendra Choudhary	65-69
12.	Surgical repair of bilateral mandibular fracture using external skeletal fixation (ESF) technique in six dromedary camels (*Camelus dromedarius*) H.S. Bhabhor, Mahendra Tanwar, P. Bishnoi, Sakar Palecha, A.K. Bishnoi, K. Kachwaha and Narendra Singh	71-75
13.	Comparative analysis of physico-chemical properties of buffalo, camel and blended (Buffalo 70%: Camel 30%) milk Vimala Choudhary, Basant Bais, Yogesh Kumar, Deepika Goklaney, Devendra Saran, Phool Kanwar, Anita Tanwar and Anuj Kumar	77-81

CONTENTS

Volume 31 **April 2024** **Number 1**

S.No.	Title of Contents and Authors	Page No.
14.	Bilateral giant subcutaneous lipomas in one-humped camel (*Camelus dromedarius*) Zabady MK, Abu-Seida AM, Al-Hizab FA, Hasseeb MM and Al-Saad A	83-86
15.	Nail avulsion in a camel-a case report Amit Sangwan, Garima Choudhary and Rajendra Yadav	87-88
16.	Effect of gender and age of dromedary camel on the nature of dermoid cyst Marwa H. Hassan and Ashraf M. Abu-Seida	89-94
17.	Standardisation of smartphone fundus imaging in dromedary camels (*Camelus dromedarius*) Bharat Bandhu, S.K. Jhirwal, Mohan Lal Sharma, Sonu Meena and P. Bishnoi	95-98
18.	News	10, 48, 56, 64, 98
19.	Instructions to Contributors	99-103

BRILLIANT BEGINNING OF THE INTERNATIONAL YEAR OF CAMELIDS 2024

The International Year of Camelids 2024 has brought tremendous excitement among camel scientists, practitioners and cameleers. In India, Dr Ilse Köhler-Rollefson and Mr Hanwant Singh of Lokhit Pashu Palak Sansthan at Camel Charisma, Sadri, India took the lead in organising two workshops. An International workshop on camel pastoralism (hybrid mode) was organised at Sadri from 5-10th January 2024. A wide range of topics ranging from camel pastoralism to culture, future and autism were discussed in addition to many more topics. The Lokhit Pashu-Palak Sansthan in collaboration with the North American Camel Ranch Owners Association (NACROA) and the generous support of Jodhana Heritage organised a day and a half long meeting about camel conservation and well being. Doug Baum and Valeri Crenshaw of NACROA actively participated in the second workshop held at Nagaur from 16-17 February 2024.

The NACROA team also visited Veterinary Institutes at Bikaner in India and in Morocco as well. The team also sought a mutual cooperation with these institutes which was considered as a most appreciated positive approach in the Year of Camelids 2024.

The National Research Centre on Camels, Bikaner organised a national symposium cum stakeholder's meet on importance, innovation and improvement in processing of nonbovine animal produce for successful entrepreneurship from 14-15 March 2024. This centre has also organised several training and workshops, animal health camps, scientist interaction, international camel festival, blog writing and MoUs with other institutes.

Another important milestone in this year is a dossier on pastoral camelid husbandry around the world: "With camelids into a sustainable future: learning from pastoralist communities" (2024, 20pp), published by Welt-Sichten, under the banner of Misereor, DITSL (German Institute for Tropical and Subtropical Agriculture) and LPP (League for Pastoral Peoples) in Germany. It offers a differentiated picture of camelid pastoralists' realities in the Old and New World and can be downloaded for free from https://www.celep.info/with-camelids-into-a-sustainable-future/

Institute for Development Studies (IDS) in University of Nairobi held a seminar on "The Moral Economy of Camel Milk Marketing" on 21st March 2024 and invited speaker was Dr. Tahira Mohamed who is a post-doctoral fellow in International Livestock Research Institute. The Institut Agronomiue et Veterinanire Hassan II is organising a scientific day of research on camelids on May 11, 2024.

The F.F.D.C.F.E. (French Federation for the Development of Camelidae in France and Europe) and Christian Schoettl, the Mayor of the small town of Janvry in Essonne are organising a camel parade in Paris for the "International Year of Camelids. The event is announced as a "festival of nomadic cultures" and supported by FAO (Food and Agriculture Organisation), UNESCO and the ICO (International Camelids Organisation). The participation and presence of 32 foreign delegations is expected, including the United States, Canada, England, Pakistan, Egypt, India, Mauritania, Senegal, Tanzania, Tunisia, Qatar, Spain, Algeria, Niger, Chad, Morocco and even Australia. During this parade, each of these delegations will be preceded by a camel, a llama or an alpaca, while folk groups accompany.

I am sharing another good news that the Journal of Camel Practice and Research has been selected for the prestigious category B27 of the 30th Gourmand Awards in the International Year of camelids 2024.

Dr. B Faye and Barbara Padalino edited a new book, "Dromedary Camel Behaviour and Welfare", Large Camel Farming: A Care-Management Guide from Breeding to Camel Products authored by Bernard Faye, Gaukhar Konuspayeva and Cécile Magnan and another edition of "A Field Manual of Camel Diseases" by Ilse Kohler Rollefson and others (likely to come up) are important publications on dromedary camels in this year. Christina Adams was interviewed by the Eastleigh Voice of Kenya and she shared her thoughts on how camel milk can help Kenyan pastoralists with new income opportunities. Many more news are expected in the year 2024 for bringing cheers to the camelids and their well wishers.

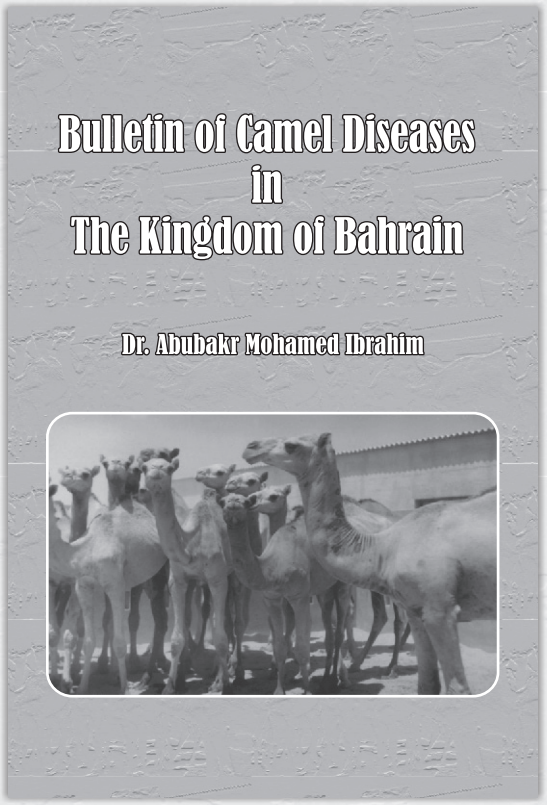
(Dr. Tarun Kumar Gahlot)
Editor

Bulletin of Camel Diseases in The Kingdom of Bahrain

This is a unique book which contains chapters on infectious and non-infectious diseases. The chapter on infectious diseases contains six sections. The section of bacterial diseases is subclassified as corynebacterium abscesses, paratuberculosis, hepatic necrobacillosis, mastitis, *Streptococcus zooepidemicus,* bacterial Infection in young camels, uterine Infection, infection of the vagina and vulva and other disorders. The section of protozoal diseases has narrations on trypanosomiasis, anaplasmosis and babesiosis. The section on parasitic infections is composed of gastrointestinal parasites in young camels, echinococcosis and mange. The section of mycotic diseases contains phycomycosis and ringworm. The section of viral diseases contains subsections on camel pox and contagious ecthyma. Edema Disease is described in miscellaneous section. The chapter on noninfectious diseases has three sections. Other section on poisoning describes pyrethroid, nitrate and toxic jaundice. The section describes zinc deficiency. The miscellaneous section describes foreign bodies, sand colic, bloat, caecal impaction, hydrocephalus, corneal opacity and osteochondroma.

About the Author

Dr. Abubakr Mohamed Ibrahim is a Veterinary Pathologist and worked for a long period as head of Royal Court Veterinary Laboratory. Kingdom of Bahrain which led to genesis of this publication out of his rich experience in diagnosing camel diseases in the Kingdom of Bahrain. This would be counted as his significant contribution and future researchers will find it easy to understand the pattern of camel diseases in this part of the world. Dr. Abubakr had majority of his publications based on camel diseases of Bahrain. Thus publication of this book would prove an important reference book for the camel practitioners and researchers.



Editor:
Dr. T.K. Gahlot

Edition: 2014

Publisher:
Camel Publishing House
67, Gandhi Nagar West,
Near Lalgarh Palace,
Bikaner-334001 Rajasthan, India
email: tkcamelvet@yahoo.com

Website:
www.camelsandcamelids.com
www.tkgahlotcamelvet.com

Price: US $ 90
INR 1000

ISBN 81-903140-2-5

SUBSCRIPTION - 2024

FOR

JOURNAL OF CAMEL PRACTICE AND RESEARCH

(Triannual In English Language, April, August and December Issue Every Year)

SUBSCRIPTION RATE - 2024

ANNUAL Rs. 4500/- or US $ 450

Note : *Subscription in Rupees is applicable to Indian subscribers only.*

Subscription Form

I want to become annual subscriber of the **Journal of Camel Practice and Research**, for/from the year 2024 ..... For this purpose I am enclosing herewith a cheque / demand draft number ..... dated ..... for Rs./US $..... in favour of "**Camel Publishing House**". The cheque or D.D. should be payable at State Bank of India, Code No. 7260, Bikaner. Payment may be made through payment portal of website www.camelsandcamelids.com or money transfer to bank account.

Name : .....

Permanent Address : .....

: .....

Country : .....

Signature : .....

Mail to :

Camel Publishing House
67, Gandhi Nagar West
Near Lalgarh Palace
Bikaner - 334001, INDIA
email : tkcamelvet@yahoo.com
website : www.camelsandcamelids.com

DOI : 10.5958/2277-8934.2024.00001.8 *Vol 31 No 1, p 1-9*

TRANSFORMATIVE TECHNOLOGIES FOR THE FUTURE OF CAMEL WELFARE: ARTIFICIAL INTELLIGENCE FOR IMPROVED DIAGNOSTICS, THERAPEUTICS AND HEALTH OUTCOMES

Ahmed Alsaleem[1], Saad Shousha[1], Mohamed Marzok[2,3], Sheryar Afzal[1], Ahmed Alameen[1], Ibrahim Albokhadaim[1] and Mahmoud Kandeel[1,4]

[1]Department of Biomedical Sciences, [2]Department of Clinical Sciences, College of Veterinary Medicine, King Faisal University, Al-Hofuf, Saudi Arabia

[3]Department of Surgery, [4]Department of Pharmacology, Faculty of Veterinary Medicine, Kafrelsheikh University, Kafrelsheikh, Egypt

ABSTRACT

This review explores the innovative application of Artificial Intelligence (AI) in advancing camel health and welfare. It investigates the utilisation of various AI methodologies, including supervised learning, unsupervised learning, reinforcement learning, and Deep Learning techniques such as Convolutional Neural Networks (CNNs), specifically tailored towards the healthcare management of camels. The review highlights significant advancements in AI for early disease detection, diagnosis, treatment, and monitoring in camels, showcasing its pivotal role in precision medicine, automated disease diagnosis, and the optimization of treatment protocols. Notably, AI is effective in evaluating the toxicological impact of chemical substances, enhancing diagnostic accuracy through image-based diagnostics, and facilitating the early prediction of diseases like *Trypanosoma evansi* using artificial neural networks. Furthermore, AI contributes to the development of camel-derived diagnostic and therapeutic products, emphasising the utility of Machine Learning in analysing complex datasets for antibodies and nanobodies discovery and optimisation. Additionally, the application of AI in camel management and welfare, including weight prediction and the assessment of camel milk adulteration, illustrates the technology's broader implications. The findings indicate that AI not only significantly enhances the accuracy and efficiency of camel healthcare and welfare but also opens new avenues for research and development in the domain of camelids. The study calls for further AI applications to fully harness AI's potential in revolutionising camel healthcare and welfare practices, especially in the tracks of camel diseases treatment and control.

Key words: Artificial intelligence, camel, diagnosis, healthcare, machine learning

Varying climate conditions in different geographic locations including Africa's deserts have a great influence on the production of the food and also how much food is consumed especially from camel sources (Boudalia *et al,* 2023). Traditionally used as a means of transportation, camels are now an essential food source for inhabitants of semiarid and desert areas. Owing to their inherent versatility and adaptability to survive in harsh environmental conditions, camels are successfully bred in both hot and cold climates (Koç, 2022) and fulfill the demand for milk and meat in both traditional camel-raising regions and Western countries (Faye, 2018; 2020). Camels are regarded as the animals of the future because of their extraordinary adaptability in varying climate conditions (Ashour and Abdel-Rahman, 2022). In addition, camel milk has proved unique efficiency in modulating and treating various human diseases (Kandeel, 2022).

Compared to other farm animals, camels get less attention from researchers and are subject to certain standards similar to those of cattle despite several differences. For instance, camel calves are reared on the same type of concentrated food just like cattle calves and milked with the aid of machines and ear tags designed for cattle. Each year, more than three million tons of milk and 600,000 tons of meat have been produced by almost 40 million camels. The number of camels surged 3.05 times more over 1961-2021 compared to poultry and goats. Camels produced roughly five times as much meat and milk within that period (FAO, 2022).

SEND REPRINT REQUEST TO MAHMOUD KANDEEL email: mkandeel@kfu.edu.sa

It is particularly challenging to apply knowledge and technologies created for cattle or other livestock species to camels and advancements in camel products since camels are primarily raised in areas where technological advancements have arrived much later and because camels and its products differ significantly from other farm animals (Baig *et al,* 2022; Gerdan Koc *et al,* 2024). Thus, it is necessary to dig deeper into scientific knowledge and design new techniques specific to camels. Moreover, diagnosis and treatment methods for camel diseases also need special attention as most of the countries where camels are reared are underdeveloped. These countries have a shortage of expert veterinarians specialised in camel disease diagnosis and treatment. This may result in incorrect diagnosis, delayed therapy, and poor efficiency of medications. The lack of standardisation and accessibility of diagnostic testing kits is a significant obstacle to accurately diagnosing camel diseases. In terms of treatment methods, optimised treatment regimens are still lacking due to very little research on camels. Scientists are using computational tools and techniques such as Artificial intelligence (AI) to conduct robust research and design new diagnostic tools and treatment methods specific to each individual (Kour *et al,* 2022).

The term "artificial intelligence" refers to the intelligence exhibited by machines or computer systems that can be used to do various tasks through the use of Natural Language Processing (NLP) and sentiment analysis. With the use of this technology, machines can comprehend the information given as well as acquire previous data on their own (Bouhali *et al,* 2022). These tools can then use this information to perform a variety of functions. Machine Learning and Deep Learning are subsets of AI, and each of these technologies has specific tasks when it comes to computing technology. AI has several benefits over conventional analytics and clinical decision-making techniques (Bohr and Memarzadeh, 2020a; Kour *et al,* 2022). In this regard, the present study has reviewed the results of the latest studies that used AI techniques in the domain of camel welfare and health.

Fig 1 shows the application of various AI domains such as Machine Learning, Deep Learning, Robotics, Speech Recognition, and NLP to the field of camel care and products. It illustrates a transition from the conceptual representation of AI as a digital brain to specific uses in camel-related contexts, with applications in disease diagnosis, healthcare, the detection of adulteration in camel products, and the development of camel-derived therapeutic products, aiming to improve management and welfare practices for camels.

Artificial intelligence in public healthcare and animal welfare sectors

Digitised approaches in the healthcare sector can provide error-free outcomes, reducing the frequency of human error. Various AI-based approaches like supervised learning, unsupervised learning, and reinforcement methods can provide a better understanding of the diseases, their data collection, and initial diagnosis (Abedi *et al,* 2020).

Notable advancements and potential development, use, and clinical integration of AI in the healthcare system of humans and animals have opened new ways for disease diagnosis and treatment. AI has shown promising results in human healthcare as it helps advance the area of precision medicine, which tailors treatment depending on genetic differences between the individuals and other variables, as well as for research and discovery of new drug candidates (Davenport and Kalakota, 2019). In the field of substances safety profiles, a Machine Learning-based program DeepTox evaluates the harmful impacts of chemical substances of drug molecules in image-based diagnostics (Bohr and Memarzadeh, 2020b; Mayr *et al,* 2016). The Tox21 Data Challenge assessed computational methods for toxicity prediction, involving 12,000 chemicals across 12 toxic effects. Deep Learning was investigated for its potential in this domain, leveraging its ability to create abstract representations of chemical features. The DeepTox pipeline, developed for this purpose, normalized chemical representations, computed descriptors, trained models, and predicted toxicity. DeepTox outperformed other methods in the challenge, showcasing the effectiveness of Deep Learning in toxicity prediction.

When it comes to solving problems related to animal health, Deep Learning is an effective tool for identifying patterns and signals, comprehending the dynamics of disease transmission, and generating computer-based decisions. The human health industry is currently using this technology, which has been developed since the 1980s (Ezanno *et al,* 2021). However, not much work has been done on the animal health sector. AI can be a useful technology to address the challenges faced by animal health sectors by evaluating the collected data on animals, infections, and their surrounding environment. Improvements in risk analysis, disease diagnosis, and individual case detection have been made possible

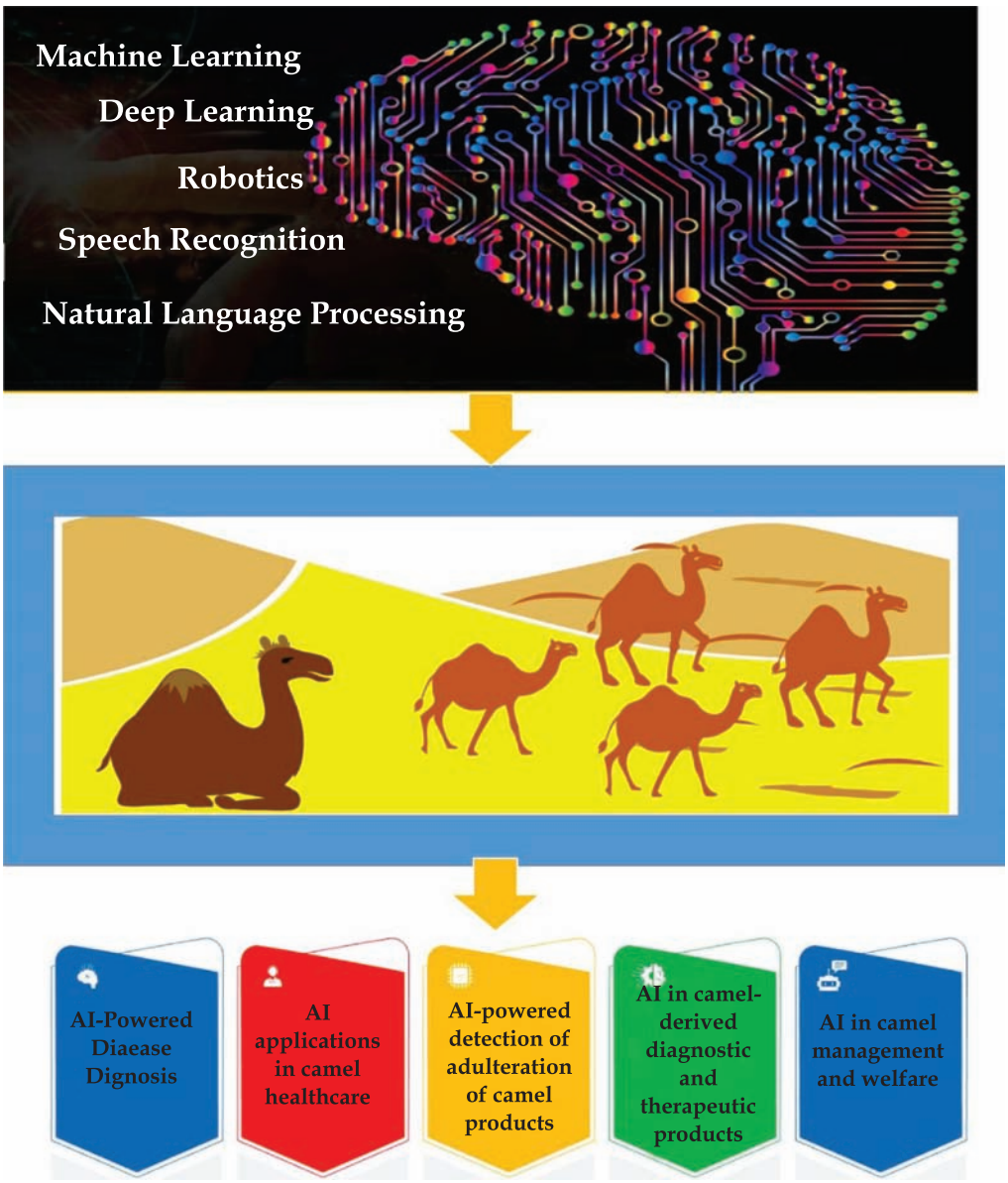


Fig 1. The various domains and applications of AI in camel welfare and healthcare. The figure is generated by using the slide team tools licensed to the corresponding author.

by developments in Machine and Deep Learning techniques (Karczewski and Snyder, 2018; Saria *et al,* 2018).

Using CNNs has demonstrated potential to enhance various diagnostic procedures within veterinary medicine. Specifically, it has effectively identified lung irregularities in feline radiographic images. This technology could significantly enhance the precision of diagnoses and the decision-making workflow in veterinary settings (Dumortier *et al,* 2022).

An emerging field of interdisciplinary study is concentrating on the intersection of Deep Learning and animal welfare. Several instances were investigated in this context, comprising automated bird count using Deep Learning (Akçay *et al,* 2020) and action recognition using a Spatial-Temporal Network for wild felines (Feng *et al,* 2021). Contemporary AI techniques are being applied to scientifically assess and evaluate the well-being of animals through the examination of extensive datasets encompassing information on animal physiology, behaviour, and health data.

The pivotal role of AI tools in automated animal activity recognition (AAR), highlighting their significance in monitoring animal behaviour in real-time was extensively discussed (Mao *et al,* 2023). Recent strides in sensing technologies and smart

computing have propelled significant advancements in AAR research. AAR using wearable sensors and Deep Learning techniques is essential for precise animal monitoring and management, offering insights into animal health and welfare and guiding care actions and environmental enhancements.

AI-powered continuous surveillance ensures at-risk patients receive ongoing observation, which facilitates the faster detection of shifts in disease biomarkers. This is especially beneficial for chronic medical conditions as it allows patients to receive proactive care with prompt treatment. A machine-learning system has reportedly been used to identify chronic hypoadrenocortism (CHA) in dogs. Due to inadequate understanding and a low level of suspicion, diagnosing CHA can be quite difficult. Using regularly recorded screening information of biomarkers including a serum chemical profile and complete blood count, Machine Learning algorithms were used to diagnose the CHA (Reagan *et al,* 2020). Similarly, canine glial cell neoplasia and non-infectious inflammatory meningoencephalitis have been distinguished using Texture Analysis (TA). Even for experienced diagnostic imaging professionals, this procedure might be extremely challenging to do due to overlapping image attributes (Wanamaker *et al,* 2021). In order to improve sensitivity, precision, and repeatability, attempts are currently being made to use radionics and AI as tools for assisting decision-making and integrate these technologies into routine clinical procedures and diagnostics (Bohr and Memarzadeh, 2020b).

AI-Powered Disease Diagnosis for Camels

Detection of any disease in its early stages can provide a better understanding and look for possible treatment options against that specific ailment. Therefore, taking rapid action with the available data can be of substantial value in developing effective possible solutions (Kumar *et al,* 2023).

A study was conducted in 2022 for the early prediction of *T. evansi* in 115 camels utilising ANNs. *T. evansi* is responsible for causing Surra, which is a severe yet neglected disease affecting camels. An immune trypanolysis test was conducted to check the production of their effective antibodies. Various elements, like age, gender, herd size, clinical history, etc., were considered as the predicting parameters of the infection. Later, an ANN was employed to test the accuracy of the predicted input parameters as the diagnostic tools of the disease. The study's results suggested that the Tansig transfer function effectively predicted the diagnostic parameters of *T. evansi* and, therefore, can be effectively utilised by veterinarians for early prediction of the disease in dromedaries (Benfodil *et al,* 2022).

The gut microbiome can also serve as a valuable marker for diagnosing various camel diseases. A very recent study was conducted to assess the camel gut microbiome and its association with multiple parameters as a diagnostic tool. Almost fifty-five camels were included in the survey, whose gut microbiome analysis was carried out using the metagenomic shotgun sequencing approach of the Fathi Camel Microbiome Project. The analysis showed substantial microbial diversity patterns, which helped establish a massive collection of Prokaryotic Metagenome Assembled Microorganisms that can serve as a reference microbiome profile. Random forest package, which is a Machine Learning tool, was used to analyse the relationship between various parameters and the microbiome. The correlation of the microbiome with the dietary component, specifically wheat consumption, revealed that the microbiome profile of camels has notable associations with diet patterns. Therefore, it was assessed that gut microbiome association with various physical parameters can be a diagnostic tool (Mubaraki, 2024).

AI holds the promise to transform animal healthcare, revolutionising veterinary services and enhance the well-being of animals. A leading area within healthcare, known as radiomics, leverages complex mathematical models to quantitatively analyse results from medical imaging. This suggests that imaging data hold insights into disease mechanisms that are beyond human visual detection (Mao *et al,* 2023). Radiomics involves analysing a vast array of medical images and modalities, requiring AI for handling the extensive data and extracting features suited for AI algorithms, blending radiomics and AI in diagnostics. The evolution of AI, particularly Deep Learning, has significantly enhanced diagnostic systems across all imaging types, with Deep Learning minimising the need for manual preprocessing and segmentation. CNNs, are notably effective, comprising layers for feature detection, selection, and integration for image classification (Mao *et al,* 2023). Radiomics integrates advanced image analysis in veterinary medicine, offering insights beyond traditional imaging by using standardised methods to analyse multi-dimensional images for correlations with genetic and pathological data. It provides both visible and non-visible features

for analysis, enhancing diagnostics, prognosis, and treatment planning (Basran and Porter, 2022).

AI-powered detection of adulteration of camel products

Camel milk is known for its high nutritional composition and benefits compared to cow and buffalo milk. However, nowadays, camel milk is being contaminated with cow milk, which poses a severe threat as it can alter the effectiveness profile of camel milk and cause serious problems in humans drinking it (Yao *et al,* 2023). Previously, adulteration in cow milk has been successfully detected using Fourier Transform Mid-Infrared Spectroscopy (FT-MIR). A study utilised FT-MIR and various AI techniques to detect adulteration in camel milk. Samples of camel milk were taken from China, Alxa League, and Inner Mongolia and were contaminated with varied concentrations of cow milk. The spectroscopy results were assessed using various AI models such as Principle Component Analysis (PCA), Linear Discriminant Analysis (LDA), Support Vector Machine (SVM), Artificial Neural network (ANN), etc. The results suggested that LDA model effectively discriminated between pure camel milk and adulterated camel milk, even in samples with minor cow milk adulteration. The quantitative model demonstrated excellent precision and accuracy within the range of 10–90 g/100 g of adulteration. Therefore, this supervised learning model can effectively be utilised in the early detection of adulteration in camel milk (Yao *et al,* 2023).

AI in drug discovery and diseases treatment in camels

The applications of AI have been focused much more on disease detection and health management so far. However, recent developments in AI-based tools and Machine Learning models have offered limited opportunities in treating camel diseases.

AI is useful in drug development. Yet, the applications in development of drugs specific for camel diseases are still not well developed. In this regard, treatment optimization and drug discovery are some of the major applications of AI. For instance, AI algorithms are useful in personalized medicine (Johnson *et al,* 2021). AI can help analyse health records, genetics, diagnostic results, and available treatment options to propose treatments for individual camels. Such approaches have proven useful in precision medicine in human health (Johnson *et al,* 2021; Rezayi *et al,* 2022).

AI has wide applicability in drug repurposing (Levin *et al,* 2020). Large-scale omics data, including genomics, transcriptomics, and proteomics data from camels, can be analysed by AI algorithms to find medications currently on the market and approved for other uses but may be modified to treat camel diseases. Chemists can then verify the therapeutic potential of these virtual compounds by having them synthesised and tested in the lab. AI models can predict the binding affinities of prospective drug candidates (Arabi, 2021) to target proteins implicated in camel diseases by analysing their molecular structures. While we tried to deliver new compounds for treating camel viral and parasitic diseases (Kandeel and Al-Taher, 2020a; Kandeel and Al-Taher, 2020b), the integration of AI in these efforts is expected to revolutionise the drug discovery for treating came diseases.

AI in camel-derived diagnostic and therapeutic products

The future of AI in camel biologicals, particularly focusing on developing of camel-derived antibodies and camel-derived nanobodies for diagnosis and treatment, represents a promising frontier in both veterinary and human medicine. Camels possess a unique immune system that produces antibodies significantly smaller than those of humans. These antibodies, known as nanobodies due to their miniature size, have garnered significant interest for their potential applications in various medical fields (Arbabi-Ghahroudi, 2022). The integration of AI into this research domain is set to revolutionise the ways in which these antibodies are discovered, optimised, and utilised.

Camel-derived antibodies have already shown considerable promise in diagnosing and treating a range of diseases. Their small size allows them to access and bind to targets in the human body that conventional antibodies cannot, making them excellent candidates for targeted therapy and imaging. For instance, nanobodies can penetrate deeper into tissues, offering superior diagnostic imaging capabilities and more effective delivery of therapeutic agents to disease sites, including tumors in cancer therapy (Al-Numair *et al,* 2022; Li *et al,* 2023). The application of AI in this field is twofold: first, in the discovery and development of new camel-derived antibodies, and second, in the optimisation of these antibodies for medical use. Machine Learning algorithms can analyse vast datasets of genetic information from camels to identify potential

antibody candidates more rapidly than traditional methods. Furthermore, AI can predict the binding affinity of these antibodies to specific disease markers, accelerating the screening process for therapeutic candidates.

AI can help antibody development through different supervised and unsupervised learning approaches (Shaver *et al,* 2022). In the realm of predicting antibody models from molecular features, two main pathways exist. The first involves using an intermediary representation of antibody structure derived from molecular modeling, along with selected features. The second predicts directly from the amino acid sequence.

Recent advancements in AI have led to the development of various methods aimed at improving protein modeling especially in the field of camel derived nanobodies. Several AI-based tools were evaluated, including general protein modeling programs like AlphaFold2, OmegaFold, ESMFold, and Yang-Server, as well as those specifically designed for antibodies, such as IgFold and Nanonet, in their ability to model camel nanobodies (Valdes-Tresanco *et al,* 2023). The findings show that while these tools are effective at modeling certain parts of the nanobody, such as the framework and the first two complementarity-determining regions (CDRs), accurately modeling the third CDR remains a significant challenge (Valdes-Tresanco *et al,* 2023).

AI in camel management and welfare

A recent study addressed the challenge of classifying Arabian camel breeds—an essential task for breeding management, genetic improvement, conservation, and traceability—by leveraging advanced Machine Learning techniques (Alfarhood *et al,* 2023). The task is notably difficult due to the absence of standardized classification criteria, the high similarity between camel breeds, and limited data and resources. To overcome these obstacles, the authors propose a method utilising CNNs to classify images of six Arabian camel breeds: Waddeh, Majaheem, Homor, Sofor, Shaele, and Shageh. They compiled, preprocessed, and annotated a novel dataset of 1073 camel images for this purpose. The study tested various popular CNN architectures, including InceptionV3, NASNetLarge, PNASNet-5-Large, MobileNetV3-Large, and EfficientNetV2 (in small, medium, and large variants), to identify the most effective model for this application. The NASNetLarge architecture emerged as the most accurate, achieving a test accuracy of 85.80% on the dataset. Building on this success, the best-performing model, NASNetLarge, was integrated into a mobile application, aiming to facilitate its practical application in real-world scenarios for classifying Arabian camel breeds.

A study compared the effectiveness of seven Machine Learning methods in estimating the weight of dromedary camels from birth to 240 days of age, utilizing 458 records of body weight and 12 biometric measurements (Asadzadeh *et al,* 2021). The ML methods evaluated were Bayesian Regularised Neural Network (BRNN), Extreme Learning (EL), Random Forest (RF), Support Vector Machine with Linear (LSVM), Polynomial (PNLSVM), and Radial Basis Kernel (RNLSVM), and Linear Regression (LR). The models' performance was assessed using various statistical metrics through a 10 repeated 10-fold cross-validation process. The accuracy rates of the ML methods were: BRNN (94.93%), EL (93.22%), RF (94.61%), LSVM (93.2%), PNLSVM (95.43%), RNLSVM (94.93%), and LR (93.15%). The study concluded that while all methods were effective in predicting camel weight, PNLSVM was the most accurate, making it the recommended model for such estimations.

A study was conducted to predict the mature weight (MW) of male and female camels using morphological traits and hybrid Machine Learning algorithms. The study utilised biometrical measurements from eight Pakistani camel breeds, including birth weight, facial length, neck length, heart girth, body length, withers height, and hind leg length, to estimate MW. The researchers applied multivariate adaptive regression splines (MARS), random forest (RF), and support vector machine (SVM) algorithms for model development and used the artificial bee colony (ABC) algorithm to optimize these Machine Learning models for better accuracy. Evaluation of the models was based on mean absolute deviation, mean absolute percentage error, coefficient of determination, and root mean square error. The findings highlighted that the ABC-SVM model was the most accurate in predicting camel MW, demonstrating the method's effectiveness and its practical and research value (Iqbal *et al,* 2023).

Future perspectives

The future of AI in camel research is a fascinating area of exploration that promises to revolutionise the way we understand and manage these unique animals. Camels have been essential to human societies for thousands of years, providing transportation, milk and meat. However, their

biological and ecological complexities have often been understudied compared to other livestock. AI, with its ability to process and analyse vast amounts of data, offers unprecedented opportunities for advancements in camel research.

One of the most promising areas of AI application in camel research is in health and disease management. Machine Learning algorithms can be trained on genetic, physiological, and environmental data to predict susceptibility to diseases, response to treatments, and optimal breeding strategies. This could lead to the development of more effective vaccines and healthcare strategies, reducing mortality and improving overall health.

In terms of breeding and genetics, AI can analyse genetic markers to identify traits associated with resilience, productivity, and adaptability to harsh environments. This could enhance selective breeding programs, helping to produce camels that are more resilient to climate change and capable of producing higher yields of milk and meat.

Nutritional research also stands to benefit from AI, as algorithms can optimise feeding strategies to improve growth rates and milk production while minimising waste and environmental impact. This could be particularly beneficial in arid regions where resources are scarce, and sustainable practices are essential.

Lastly, AI technologies such as robotics and autonomous systems could be employed for monitoring and managing camel herds in remote or harsh environments. Drones, for example, could be used for aerial surveys, providing real-time data on herd size, health and movement patterns.

Conclusion

This review underscores the transformative impact of AI on the health and welfare of camels, demonstrating significant advancements in diagnostic accuracy, disease prediction, and treatment optimization. AI's capabilities, from Machine Learning algorithms to Deep Learning techniques enhanced camel management practices, including weight estimation and milk adulteration detection. Despite these successes, challenges such as the need for comprehensive datasets and deeper applications in the fields of treatment of diseases. The review highlights the potential of AI to revolutionise the camel practice, offering promising avenues for improving camel health outcomes and welfare, and setting a precedent for the application of AI in camel healthcare.

Funding

This work was supported through the Annual Funding track by the Deanship of Scientific Research, Vice Presidency for Graduate Studies and Scientific Research, King Faisal University, Saudi Arabia [Project No. GRANT6,013].

Acknowledgements

This work was supported by the Deanship of Scientific Research, Vice Presidency for Graduate Studies and Scientific Research, King Faisal University, Saudi Arabia under Annual Research Track (Grant No. GRANT6,013).

Conflicts of Interest

The authors declare no conflict of interest.

Data Availability Statement

Data is available in the manuscript. Further details can be requested from the corresponding author.

References

Abedi V, Khan A, Chaudhary D, Misra D, Avula V, Mathrawala D, Kraus C, Marshall KA, Chaudhary N, Li X, Schirmer CM, Scalzo F, Li J and Zand R. Using artificial intelligence for improving stroke diagnosis in emergency departments: a practical framework. Therapeutic Advances in Neurological Disorders. 2020; 13:1756286420938962.

Akçay HG, Kabasakal B, Aksu D, Demir N, Öz M and Erdoğan A. Automated Bird Counting with Deep Learning for Regional Bird Distribution Mapping. Animals. 2020; 10:1207.

Al-Numair NS, Theyab A, Alzahrani F, Shams AM, Al-Anazi IO, Oyouni AAA, Al-Amer OM, Mavromatis C, Saadeldin IM, Abdali WA and Hawsawi YM. Camels' biological fluids contained nanobodies: promising avenue in cancer therapy. Cancer Cell International. 2022; 22:279.

Alfarhood S, Alrayeh A, Safran M, Alfarhood M and Che D. Image-Based Arabian Camel Breed Classification Using Transfer Learning on CNNs. Applied Sciences. 2023; 13:8192.

Arabi AA. Artificial intelligence in drug design: algorithms, applications, challenges and ethics. Future Drug Discovery. 2021; 3:FDD59.

Arbabi-Ghahroudi M. Camelid Single-Domain Antibodies: Promises and Challenges as Lifesaving Treatments. International Journal of Molecular Sciences. 2022; 23.

Asadzadeh N, Bitaraf Sani M, Shams Davodly E, Zare Harofte J, Khojestehkey M, Abbaasi S and Shafie Naderi A. Body weight prediction of dromedary camels using the machine learning models. Iranian Journal of Applied Animal Science. 2021; 11(3):605-614.

Ashour G and Abdel-Rahman SM. Camels as a miracle key

for animal production sustainability in Egypt. Egyptian Journal of Animal Production. 2022; 59:33-43.

Baig D, Sabikhi L, Khetra Y and Shelke PA. Technological challenges in production of camel milk cheese and ways to overcome them – A review. International Dairy Journal. 2022; 129:105344.

Basran PS and Porter I. Radiomics in veterinary medicine: Overview, methods, and applications. Veterinary Radiology and Ultrasound. 2022; 63 Suppl 1:828-839.

Benfodil K, Benbouras MA, Ansel S, Mohamed-Cherif A and Ait-Oudhia K. Prediction of *Trypanosoma evansi* infection in dromedaries using artificial neural network (ANN). Veterinary Parasitolology. 2022; 306:109716.

Bohr A and Memarzadeh K. Artificial intelligence in healthcare. Academic Press. 2020a.

Bohr A and Memarzadeh K. The rise of artificial intelligence in healthcare applications. In: Artificial Intelligence in Healthcare. Elsevier. 2020b; pp 25-60.

Boudalia S, Gueroui Y, Zebsa R, Arbia T, Chiheb AE, Benada Mh, Hadri Z, Youcefi A and Bousbia A. Camel livestock in the Algerian Sahara under the context of climate change: Milk properties and livestock production practices. Journal of Agriculture and Food Research. 2023; 11:100528.

Bouhali O, Bensmail H, Sheharyar A, David F and Johnson JP. A Review of Radiomics and Artificial Intelligence and Their Application in Veterinary Diagnostic Imaging. Veterinary Sciences. 2022; 9:620.

Davenport T and Kalakota R. The potential for artificial intelligence in healthcare. Future Healthc Journal. 2019; 6:94-98.

Dumortier L, Guepin F, Delignette-Muller ML, Boulocher C and Grenier T. Deep learning in veterinary medicine, an approach based on CNN to detect pulmonary abnormalities from lateral thoracic radiographs in cats. Sci Rep. 2022; 12:11418.

Ezanno P, Picault S, Beaunee G, Bailly X, Munoz F, Duboz R, Monod H and Guegan JF. Research perspectives on animal health in the era of artificial intelligence. Veterinary Research. 2021; 52:40.

FAO. Crops and livestock products. https://www.fao.org/faostat/en/#data/QCL/visualize. Accessed 17 February 2024. 2022.

Faye B. The enthusiasm for camel production. Emirates Journal of Food and Agriculture. 2018; pp 249-250.

Faye B. How many large camelids in the world? A synthetic analysis of the world camel demographic changes. Pastoralism. 2020; 10:1-20.

Feng L, Zhao Y, Sun Y, Zhao W and Tang J. Action Recognition Using a Spatial-Temporal Network for Wild Felines. Animals (Basel). 2021; 11:485.

Gerdan Koc D, Koc C, Polat HE and Koc A. Artificial intelligence-based camel face identification system for sustainable livestock farming. Neural Computing and Applications. 2024; 36:3107-3124.

Iqbal F, Raziq A, Zil EH, Tirink C, Fatih A and Yaqoob M. Using the artificial bee colony technique to optimize machine learning algorithms in estimating the mature weight of camels. Tropical Animal Health and Production. 2023; 55:86.

Johnson KB, Wei WQ, Weeraratne D, Frisse ME, Misulis K, Rhee K, Zhao J and Snowdon JL. Precision Medicine, AI, and the Future of Personalized Health Care. Clinical and Translational Science. 2021; 14:86-93.

Kandeel M. Antidiabetic, Anticolitis and Anticancer Activity in Camel Milk: A Systematic Analysis. Journal of Camel Practice and Research. 2022; 29:365-372.

Kandeel M and Al-Taher A. Deoxyuridine 5-Monophosphate (dUMP) metabolising enzyme and the bifunctional dihydrofolate reductase-thymidylate synthase in camels and *Trypanosoma evansi*. Journal of Camel Practice and Research. 2020a; 27:185-192.

Kandeel M and Al-Taher A. Metabolic drug targets of the cytosine metabolism pathways in the dromedary camel (*Camelus dromedarius*) and blood parasite *Trypanosoma evansi*. Tropical Animal Health and Production. 2020b; 52:3337-3358.

Karczewski KJ and Snyder MP. Integrative omics for health and disease. Nature Reviews Genetics. 2018; 19:299-310.

Koç A. Camel Milk Production System in Türkiye. Turkish Journal of Agriculture-Food Science and Technology. 2022; 10:2531-2538.

Kour S, Agrawal R, Sharma N, Tikoo A, Pande N and Sawhney A. Artificial Intelligence and its Application in Animal Disease Diagnosis. Journal of Animal Research. 2022; 12:1-10.

Kumar Y, Koul A, Singla R and Ijaz MF. Artificial intelligence in disease diagnosis: a systematic literature review, synthesizing framework and future research agenda. Journal of Ambient Intelligence and Humanized Computing. 2023; 14:8459-8486.

Levin JM, Oprea TI, Davidovich S, Clozel T, Overington JP, Vanhaelen Q, Cantor CR, Bischof E and Zhavoronkov A. Artificial intelligence, drug repurposing and peer review. Nature Biotechnology. 2020; 38:1127-1131.

Li S, Hoefnagel SJM and Krishnadath KK. Single domain Camelid antibody fragments for molecular imaging and therapy of cancer. Front Oncol. 2023; 13:1257175.

Mao A, Huang E, Wang X and Liu K. Deep learning-based animal activity recognition with wearable sensors: Overview, challenges, and future directions. Computers and Electronics in Agriculture. 2023; 211:108043.

Mayr A, Klambauer G, Unterthiner T and Hochreiter S. DeepTox: Toxicity Prediction using Deep Learning. Frontiers in Environmental Science. 2016; 3.

Mubaraki FA. Extensive novel diversity and phenotypic associations in the dromedary camel microbiome are revealed through deep metagenomics and machine learning. bioRxiv. 2024:2024.2002. 2005.578850.

Reagan K, Reagan B and Gilor C. Machine learning algorithm as a diagnostic tool for hypoadrenocorticism in dogs. Domestic Animal Endocrinology. 2020; 72:106396.

Rezayi S, S RNK and Saeedi S. Effectiveness of Artificial Intelligence for Personalized Medicine in Neoplasms:

A Systematic Review. BioMed Research International. 2022; 2022:7842566.

Saria S, Butte A and Sheikh A. Better medicine through machine learning: What's real, and what's artificial? vol 15. Public Library of Science San Francisco, CA USA. 2018.

Shaver JM, Smith J and Amimeur T. Deep Learning in Therapeutic Antibody Development. Artificial Intelligence in Drug Design. 2022; 2390:433-445.

Valdes-Tresanco MS, Valdes-Tresanco ME, Jimenez-Gutierrez DE and Moreno E. Structural Modeling of Nanobodies: A Benchmark of State-of-the-Art Artificial Intelligence Programs. Molecules. 2023; 28.

Wanamaker MW, Vernau KM, Taylor SL, Cissell DD, Abdelhafez YG and Zwingenberger AL. Classification of neoplastic and inflammatory brain disease using MRI texture analysis in 119 dogs. Veterinary Radiology & Ultrasound. 2021; 62:445-454.

Yao Z, Zhang X, Nie P, Lv H, Yang Y, Zou W and Yang L. Identification of milk adulteration in camel milk using FT-Mid-Infrared Spectroscopy and Machine Learning models. Foods. 2023; 12:4517.

ANIMAL HEALTH CAMP AND FARMERS-SCIENTISTS INTERACTION

Event 1: Animal health camp and farmer-scientist interaction meet was organised on 18.01.2024 at Amarpura village of Pugal tehsil.

Event 2: Animal Health Camp and Farmer-Scientist Interaction Meet was organised at Boogdi, Choudhary Swargiye Shree Laxman Ram Maderna Smriti Vishal Pashu Mela at Shree Laxman Nagar, Chadi and Surrounding villages in Jodhpur District on 31st January 2024.

Event 3: Animal health camp and farmers-scientists interaction meet was organised at Sawta and Sam village of Jaisalmer from 9 to 10 February 2024.

Event 4: Animal health camp and scientist-farmers interaction meet at Nagaur Pashu Mela on 20-02-2024

MEETING WITH NGOS AND GOVT ORGANISATIONS

Event 1: Meeting was held with representatives from Urmul Seemant Samiti (Bajju) and Foundation for Ecological Security (FES) on 13 January 2024. Issues on camel milk marketing and conservation of pasturelands for camel herders are discussed in detail.

Event 2: Meeting with representatives from Food Safety and Standards Authority of India (FSSAI) was held on 14 March 2024. Issues on camel milk quality and marketing were discussed in detail.

CAMEL CONSERVATION AND WELL-BEING WORKSHOP HELD IN NAGAUR, INDIA

An above titled workshop was held in the historic Nagaur Fort and during the Nagaur Fair on February 16-17th, 2024 in collaboration with LPPS, NACROA and Jodhana Heritage. The workshop was aimed to discuss the topics relevant to the camels of Rajasthan and their welfare, i.e. improving the role of women stakeholders in Rajasthan, Increasing the market for camel milk, improving camel well-being in Rajasthan, increasing access to grazing for camels in Rajasthan. The workshop started with a welcome remarks by Hanwant Singh Rathore (Director of LPPS and CEO Camel Charisma) and Valeri Crenshaw (Secretary General, North American Camel Ranch Owners Association). There were various eminent speakers who delivered lectures on the diverse topics such as Rajasthan's Camel Culture and its Uniqueness, current status and trend of the camel in India, solutions for the camel economy, camel herders' perspective, international perspective on camel well-being, the search for cruelty-free camel milk, Camel Charisma's Standards for ethical milk and community camel health centre.

DOI : 10.5958/2277-8934.2024.00002.X Vol 31 No 1, p 11-16

ROLE OF DIAGNOSTIC IMAGING IN DIAGNOSIS OF CAMEL LAMENESS: CURRENT STATUS AND FUTURE PROSPECTIVES

Marwa H. Hassan[1] and Ashraf M. Abu-Seida[2,3]

[1]Department of Veterinary Clinical Sciences, Faculty of Veterinary Medicine, Jordan University of Science and Technology, Irbid, PO: 22110, Jordan

[2]Galala University, Animal Research Facility, Suez, Egypt

[3]Department of Surgery, Anaesthesiology and Radiology, Faculty of Veterinary Medicine, Cairo University, Giza, PO: 12211, Egypt

ABSTRACT

Camel lameness constitutes a major welfare problem and has a negative economic impact. Lameness in dromedaries has a different pattern than in cattle and horses, therefore it's diagnosis is a big challenge for veterinarians. Radiography and ultrasonography (US) are well-established in dromedaries, whereas computed tomography (CT) and magnetic resonance imaging (MRI) are becoming increasingly common. CT and MRI accurately describe the bones and soft tissues, eliminate structural superimposition in the dromedary camel's limbs and allow for the assessment of minute ligamentous and tendentious structures that are inaccessible by US. However, US and MRI are useful for assessing the articular cartilage that is not evident on normal CT images. Ultrasonography is a useful tool for assessing soft tissues, articular cartilage and bone shapes. However, CT and MRI may be used when US data are unclear or to assess inaccessible regions of the camel's limbs. MRI and CT are becoming more widely recognised as very accurate imaging techniques in camel practice. Nevertheless, restricted accessibility, the necessity for animal general anaesthesia and expensive expenses reduce the usefulness of these techniques in camels. As a result, all previous research on the use of CT and MRI in dromedary camels was done on cadavers. Future clinical trials are strongly recommended to document the usefulness of these techniques in diagnosis of camel lameness. Furthermore, the availability of adequate or customised CT and MRI machines for use in camel practice is essential. An atlas of normal CT and MRI scans of all regions of the musculoskeletal system in camels is desperately needed to cover the diagnostic imaging gap in camel practice. This narrative review describes the current status and future prospective of using diagnostic imaging techniques in diagnosis of camel lameness.

Key words: Camel, computed tomography, lameness, magnetic resonance imaging, radiography, ultrasonography

Lameness in camels has a negative economic impact, is a big welfare concern and emerges in a different pattern than in cattle and horses due to the unique anatomy, physiology, biomechanics, geoclimatic adaptability and usage of camel limbs (Gahlot, 2000; Janis *et al,* 2002). The economic losses include; low milk production, decreased reproductive performance, growth retardation, culling of the camel from competition or farm, decreased physiological vitality of the camel and increased costs for caring and treating the diseased animal (Al-Juboori, 2013).

Camel lameness has a wide range of causes, including physical trauma, diet, illness and fractures (Singh and Gahlot, 1997; Sharma and Sharma, 2006; Levine *et al,* 2007; Mohamed, 2012). According to the camel's age, traumatic injuries, fractures, soreness and punctures to the foot were the most prevalent causes of lameness in juvenile racing camels, whereas abscesses and muscle spasms were the most common causes in adult racing camels. Moreover, lameness of the distal limb area in dromedary camels is rather common (Al-Juboori, 2013).

Lameness is the fourth most economically important condition in camel cows, followed by mastitis, reproductive disorders and metabolic illnesses (Cynthia, 2005). The total prevalence of acute and chronic lameness in camel is 9.39% and 2.50%, respectively. Lameness was more common in forelimbs (67.76%) than in hindlimbs (32.24%) (Al-Juboori, 2013). The prevalence of musculoskeletal disorders is 10.14% and 55.62% in camels brought into clinics and field cases, respectively (Singh and Gahlot, 1997). In a recent survey, the incidence of the distal limb lameness is 28.22% and the foot disorders are the most common diseases causing lameness (59.05%) followed by the fetlock and metacarpus

SEND REPRINT REQUEST TO ASHRAF M. ABU-SEIDA email: ashrafseida@cu.edu.eg & ashrafseida@yahoo.com

(MC)/metatarsal (MT) disorders (40.94%) (Mostafa, 2020).

Imaging methods give critical pathologic and physiologic information required to treat certain diseases. There are two types of imaging methods: anatomical and physiological. Radiology, ultrasonography, CT scanning and MRI are all examples of anatomic imaging modalities. Scintigraphy and thermography are two physiological imaging modalities. To provide a definitive diagnosis of orthopedic disorders in camels, a full orthopedic examination must be combined with appropriate imaging modalities (Ibrahim *et al,* 2019). Radiography and US are well-established in dromedaries, whereas CT and MRI are gaining popularity. In camels, CT delivers far more bone information than any other imaging method (Bhabhor and Tanwar, 2023). However, US and MRI remain the best alternatives for soft tissue imaging (El Nahas *et al,* 2024). This narrative review describes the current status and future prospective of using anatomic diagnostic imaging techniques in diagnosis of camel lameness.

Data collection

This narrative review was based on a comprehensive literature search for all relevant English-language articles on the use of imaging methods in diagnosis of camel lameness in February, 2024. The literature relevant to this issue for the previous 35 years (1989-2024) was searched in PubMed, Scopus and Google Scholar databases. This review examined and critically assessed the relevant literature. The search phrases included "camel", "radiography", "ultrasonography", "computed tomography", "magnetic resonance imaging" and "lameness".

Radiography

Radiologic techniques are the most routinely utilised to assess lameness in camels. Plain radiography is traditionally used in camels for diagnosis of fractures (Squire and Boehm, 1991), congenital limb anomalies like supernumerary digits (Bani-Ismai *et al,* 1999), angular fetlock deformity (Fahmy *et al,* 2006), panosteitis (Levine *et al,* 2007) and assessment of the normal structures of joints (Alsafy *et al,* 2018; 2021).

Contrast radiography offers information regarding articular cartilage and surfaces and is especially useful for detecting if subchondral cysts interact with the joint and outlining subcutaneous pathways (Mostafa *et al,* 1993). Puncturing and contrast arthrography of the interphalangeal, fetlock, intercarpal and radiocarpal joints are very simple compared to those of the shoulder and elbow joints (Mostafa *et al,* 1993; Al-Sobayil *et al,* 2015). In dromedary camels, arthrographic-guided approaches provide significant benefits for identifying anatomical landmarks and selecting the best intra-articular (IA) injection location in the hindlimb. Furthermore, a reference technique for camels is developed, which differs from the approach for cattle and horses (Al-Sobayil *et al,* 2021).

Radiography, either plain or contrast, is the most available and commonly used diagnostic imaging tool in both normal and injured camel limbs. Nevertheless, more future studies are recommended to investigate its role in diagnosis of various orthopedic disorders in camels.

Ultrasonography

Ultrasonography is widely utilised as a safe and non-invasive diagnostic method in farm animal practice (Abu-Seida, 2012; Abu-Seida, 2016; Hassan and Abdelgalil, 2020; Hassan *et al,* 2024). Compared to other farm animals, ultrasonography is underutilised in camel management; yet, it can help veterinarians with more precise diagnosis and treatment of a variety of dromedary disorders (Abu-Seida, 2016). Ultrasonography is particularly effective in assessing tendons and ligaments, although it may also be used to assess muscle, cartilage and bone shapes (Abu-Seida *et al,* 2012).

Several investigations have been undertaken on the normal carpal joint (Kassab, 2008), tarsus (Hagag *et al,* 2013) and foot (Abu-Seida *et al,* 2012) of camels. However, no investigations on ultrasonography diagnosis of lameness in camels have been recorded. Ultrasound can clearly identify the *extensor carpi radialis, extensor digitorum communis* and *extensor digitorum lateralis* tendons on the dorsal surface of the carpus and the distal radius. Meanwhile, the *extensor carpi obliqus* tendon is difficult to identify, whereas the *ulnaris lateralis* tendon is visible laterally. Furthermore, the *flexor carpi radialis, flexor digitorum superficialis* and *flexor digitorum profundus* tendons may be seen on the palmar side (Kasseb, 2008). Ultrasonography of the foot can scan the common digital extensor tendon and its medial as well as lateral branches, superficial digital flexor tendon (SDFT), deep digital flexor tendon (DDFT), synovial fluid, tendon sheath, phalanges, digital cushions (DC) and interdigital septum (Abu-Seida *et al,* 2012).

Arthrocentesis plays a crucial role in diagnosis and treatment of most joint disorders in camels (Badawy and Eshra, 2016). To increase the success

rate, feasibility, accuracy and simplicity of execution of this technique, it should be conducted under US guidance. A high-frequency ultrasound-guided approach has recently been recommended to ensure accurate needle placement for arthrocentesis of the lateropalmar pouch of the radiocarpal joint via a lateral approach in an extended position. This approach has many advantages like low risk of damaging the articulating cartilage surface and the elimination of inadvertent communication with the extensor carpi radialis, common digital extensor and DDFT sheaths (King *et al,* 2022). Also, a lateral arthrocentesis approach through the proximal palmar/plantar pouches of the metacarpophalangeal/ metatarsophalangeal and proximal interphalangeal joints is advised under ultrasonography guidance. This method prevents the possible needle harm to the articulating joint cartilage and other adjacent joint components such tendons, blood vessels and nerves (Al Aiyan *et al,* 2023).

A recent study has been described the ultrasonography findings of the tendons and ligaments on the palmar (plantar) aspect of the cannon and phalangeal area of one-humped camels. SDFT, DDFT and suspensory ligament (SL) differ in form and echogenicity across the cannon bone's proximal, middle and distal thirds, as well as the phalangeal area. The authors reported that there is no discernible difference between live animals and cadaveric samples (Gadallah *et al,* 2023). Although, US is useful for assessing soft tissues, articular cartilage and bone shapes in camels, US cannot penetrate minute ligamentous and tendentious structures such as the axial collateral ligaments, ligaments supporting the proximal sesamoid bones and the palmar/plantar aspects of the interphalangeal joints (El Nahas *et al,* 2024).

The ultrasonography data obtained from previous studies on musculoskeletal system of camels will be used as a reference tool for practicing veterinarians as well as future investigations on camel orthopaedic injuries. Nevertheless, there is a significant lack of use of ultrasound to identify the rest of the musculoskeletal structures in camels. In addition, there is a lack of clinical research dealing with the use of US in diagnosing and treating orthopaedic problems in camels. Therefore, it is recommended to conduct future studies on the normal US characteristics of all parts of musculoskeletal system in camels and on the use of US in diagnosing and treating musculoskeletal injuries in dromedary camel.

Computed Tomography (CT)

It is a method that employs extremely tiny X-ray beams from many different angles around the body (known as slices) that are rebuilt by a computer to generate images. As a result, CT scanner produces the best possible pictures of the limbs, joints, skull, sinus cavities and neck. CT has several advantages, including the ability to portray precise cross-sectional anatomy, better contrast resolution and computer reformatting, making it a potentially useful diagnostic method (El-Shafey and Kassab, 2013).

Computed Tomographic Arthrography (CTA) is useful and highly sensitive for the evaluation of the clinically important osseous and soft tissues structures in camels (Badawy, 2016). The only difference between the plain CT and CTA is the intra-articular injection of contrast medium (non-ionic iodinated group) prior to CT scans for enhancement of the characters of CT images (Puchalski, 2012). Post contrast CT images provide better delineation of the intra-articular ligaments, capsular recesses, pre-articular soft tissues, articular margins and articular defects (Badawy *et al,* 2016). Camel CTA shows great promise. It has the potential to significantly improve both the evaluation of athletic animal performance and the identification of musculoskeletal issues in camels. In the subject of camel anatomy, it might disclose the varied anatomical aspects of joints (Badawy, 2016; Badawy *et al,* 2016). Although CT and CTA are now frequently utilised in the diagnosis of horse lameness (Crijns *et al,* 2010), their application in the examination of camel orthopedic disorders remains limited. This is because it relies on availability, the necessity for the animal to be anaesthetised for scanning and the paucity of literature concerning the normal and clinical CT data of particular camel joints (Badawy *et al,* 2016).

All hard and soft tissues in the pastern and coffin joints of the camel clearly appeared in CT images; however, the plantar ligaments of the pastern joint and ligaments of the navicular cartilage were identified on CT images. The CT soft tissue window visualised the joint cavity and their pouches and tendon sheath of the flexor tendons better than the bone window CT (Alsafy *et al,* 2021).

The traditional dorsal arthrocentesis approach of the metacarpophalangeal, metatarsophalangeal, proximal interphalangeal and distal interphalangeal joints, has limitations due to the risk of damaging the tendon structures and articular cartilage, which can lead to joint degeneration. A lateral arthrocentesis approach *via* the proximal palmar/plantar pouches

of the metacarpophalangeal/metatarsophalangeal and proximal interphalangeal joints is recommended after CT images (Al Aiyan *et al,* 2023). This approach eliminates the potential needle injury to the articulating joint cartilage and other surrounding joint structures, such as tendons, blood vessels and nerves.

The 3D CT creates detailed pictures of the digit bones; while the angiograph render volume 3D of the CT depicts the relationship between the digit's arteries, bones and tissues. As a result, these imaging techniques offer a comprehensive description of the origin, distribution and course of the digital bones and arteries, as well as their relationships with surrounding tissues in the dromedary camel (El-Gendy *et al,* 2022).

Magnetic Resonance Imaging (MRI)

It is a very detailed anatomic imaging technology. There are two types of MRI magnets: low-field and high-field. High-field scanners provide a stronger signal and higher resolution images in less time than low-field scanners. MRI for orthopaedic disorders is conducted in multiple acquisition sequences. Each sequence conveys distinct anatomical, physiological and pathologic information. The proton density and T1- as well as T2-weighted images, are the most commonly used sequences. Proton density offers the highest anatomical detail. T1-weighted pictures show the structural qualities of bone and soft tissues, but T2-weighted images show the fluid properties of tissues and are good at identifying synovial effusions, cysts and oedema. Special sequences can help explain or emphasise a lesion (Elemmawy *et al,* 2020). MRI is the most adaptable and useful imaging technique for the diagnosis of locomotor injuries in equine practice (Elemmawy *et al,* 2020; Abu-Seida and Elemmawy, 2023). However; veterinary literature on the MRI of the dromedary camel limbs is limited (Ibrahim *et al,* 2019; Al Mohamad *et al,* 2021).

El-Shafey and Al-Galil (2012) described the normal anatomical structures of the camel's digits and footpad using MRI. They used a magnet of 0.2 Tesla and T1 weighted sequence to produce sagittal, dorsopalmar and transverse MRI images of three camel cadaver digits. The distal limbs were investigated using a 1 Tesla MRI scanner and the acquired MR images clearly scanned the soft tissues of the dromedary camels' pastern and coffin joints (Ibrahim *et al,* 2019). However, the MR scans did not show the palmar/plantar ligaments of the pastern joint or the navicular cartilage ligaments (Ibrahim *et al,* 2019).

MR imaging was performed on the brain of a newborn camel (Arencibia *et al,* 2004) and adult camels (Arencibia *et al,* 2005; Cartiaux *et al,* 2023) using a superconducting magnet with field strength of 1.5-3 T and a human head coil. The authors obtained exceptional soft tissue contrast and anatomical features in the camel's brain and adjacent tissues.

Recently, the soft and osseous components of the dromedary camel tarsus were clearly delineated on MRI images and correlated closely to gross anatomic sections (Al Mohamad *et al,* 2021). In comparison to radiography and US, MRI can examine many structures such as the transverse inter-tarsal ligaments, the talocalcaneal ligament, the short dorsal ligament, branches of the short medial and lateral collateral ligaments and the tarsometatarsal ligaments. CT and MRI eliminate structural superimposition in the distal limbs of dromedary camels and allow for the assessment of minute ligamentous and tendentious structures that are inaccessible by US, such as the axial collateral ligaments, ligaments supporting the proximal sesamoid bones and the palmar/plantar aspects of the interphalangeal joints. US and MRI were useful for assessing the articular cartilage that was not evident on normal CT images (El Nahas *et al,* 2024). CT and MRI accurately detect and describe the bones and soft tissues that make up the dromedary camel's distal limbs. CT and MRI may be used when US findings are unclear or to assess inaccessible regions of the camel's distal limbs (El Nahas *et al,* 2024).

The use of MRI in camel practice is currently limited and no clinical studies have been undertaken on the use of MRI in camel orthopedic disorders due to practical issues with image capture. Limited accessibility, need for animal general anaesthesia and high costs diminish the valuable using of CT and MRI. Therefore, the availability of adequate or customised CT and MRI machines for use in camel practice is essential. Moreover, an atlas of normal CT and MRI scans of all musculoskeletal tissues in camels is desperately needed to cover the diagnostic imaging gap in camel practice.

Anatomic diagnostic imaging techniques play a crucial role in assessment of various musculoskeletal structures in camels. Although, radiography and US are the commonly used diagnostic imaging modalities in camel practice, there is a growing awareness in the use of CT and MRI as high definitive diagnostic imaging techniques. Nevertheless; limited accessibility, need for animal general anaesthesia and high costs diminish the valuable using of CT

and MRI in the camel practice. Radiography, either plain or contrast, is the most available diagnostic imaging tool for diagnosis of orthopaedic disorders in camels; however, US is useful for assessing soft tissues, articular cartilage and bone shapes. CT and MRI may be used when US data are unclear or to assess inaccessible regions of the camel's distal limbs. CT and MRI accurately describe the bones and soft tissues as well as eliminate structural superimposition in the distal limbs of dromedary camels and allow for the assessment of minute ligamentous and tendentious structures that are inaccessible by US. MRI and US are useful for assessing the articular cartilage that is not evident on normal CT images. Future clinical trials are strongly recommended to document the usefulness of these techniques in diagnosis of camel lameness. Furthermore, the availability of adequate or customised CT and MRI machines for use in camel practice is essential. An atlas of normal CT and MRI scans of all musculoskeletal tissues in camels is desperately needed to cover the diagnostic imaging gap in camel practice.

Conflicts of Interest

The authors declare no conflict of interest.

References

Abu-Seida AM. Ultrasonographic diagnosis of some scrotal swellings in bulls. Pakistan Veterinary Journal. 2012; 32(3):378-381

Abu-Seida AM. A systemic review on ultrasonographic applications in camels. Journal of Camel Practice and Research. 2016; 23(1):139-146. DOI: 10.5958/2277-8934.2016.00023.0

Abu-Seida AM and Elemmawy Y. MRI features of multiple phalangeal disorders in a draft horse – a case report. Veterinarski Arhiv. 2023; 93(3):381-388. DOI: 10.24099/vet.arhiv.1731

Abu-seida AM, Mostafa A and Tolba AR. Anatomical and ultrasonographical studies on tendons and digital cushios of normal phalangeal region in camels (*Camelus dromedarius*). Journal of Camel Practice and Research. 2012; 19:169-175.

Al Aiyan A, King FC, Aldarwich A, Kishore U and Shawaf T. Arthrocentesis approaches to the phalangeal joints of the one humped camel (*Camelus dromedarius*). Scientific Reports. 2023; 13:17354. doi.org/10.1038/s41598-023-44391-1

Al-Juboori A. Prevalence and etiology of lameness in racing camels (*Camelus dromedarius*) in Abu Dhabi Emirate. Journal of Camelid Science. 2013; 6:116-121.

Al Mohamad ZA, Hagag U, Tawfiek MG and El Nahas AE. Magnetic resonance imaging of the normal dromedary camel tarsus. BMC Veterinary Research. 2021; 17(1): 101. DOI/10.1186/s12917-021-02811-2

Alsafy MA, El-Gendy SA and Kamal B. Morphological, radiographic and computed tomographic evaluation of the metatarsophalangeal joint of the one-humped camel. Anatomia, Histologia, Embryologia. 2018; 47(6): 537-543. https://doi.org/10.1111/ahe.12394

Alsafy MAM, El-Gendy SA and Kamal B. Computed tomographic and radiographic morphology of the pastern and coffin joints of One-Humped Camel (*Camelus dromedarius*). Anatomia, Histologia, Embryologia. 2021; 50(1):108-113. doi: 10.1111/ahe.12607

Al-Sobayil F, Sadan MA, El-Shafaey EA and Allouch J. Intra-articular injection in the hind limb joints of dromedary camels (*Camelus dromedarius*) using anatomical and arthrographic-guided landmarks. Veterinary World. 2021; 14(8):2055-2063. doi: 10.14202/vetworld.2021.2055-2063.

Alsobayil FA, Allouch JA and Ahmed AF. Articular puncture techniques and contrast arthrography of the forelimb in dromedary camels (*Camelus dromedarius*). Pakistan Veterinary Journal. 2015; 35:28-32

Arencibia A, Rivero, MA, Ramírez JA, Gil F, Gutierrez C, Orós J, Latorre R and Vázquez, JM. Magnetic resonance imaging of the normal brain in a newborn dromedary camel. Veterinary Journal. 2004; 168(3):353-357. DOI10.1016/j.tvjl.2003.06.001

Arencibia A, Rivero MA, Gil F, Ramírez JA, Corbera JA, Ramírez G and Vázquez JM. Anatomy of the cranioencephalic structures of the camel (*Camelus dromedarius*) by imaging techniques: A magnetic resonance imaging study. Journal of Veterinary Medicine Series C: Anatomia Histologia, Embryologia. 2005; 34(1):52-55. DOI10.1111/j.1439-0264.2004.00572.x

Badawy AM. Computed tomographic arthrography in camel: promises and challenges. Austin Journal of Radiology. 2016; 3(2):1049.

Badawy AM and Eshra EA. Comparison of three techniques for arthrocentesis of the carpal joint in dromedary camels: a prospective study. Journal of Advanced Veterinary Research. 2016; 6:53-59

Badawy AM, Marzok MA and Eshra EA. Computed tomographic arthrography of the normal dromedary camel carpus. Veterinary and Comparative Orthopaedics and Traumatology. 2016; 29:188-194.

Bani-Ismail Z, Hawkins JF and Siems JJ. Surgical correction of polydactyly in a camel (*Camelus dromedarius*). Journal of Zoo and Wildlife Medicine. 1999; 30(2):301-304.

Bhabhor HS and Tanwar M. Imaging studies of cadaver mandible of camel and its correlation with mandibular fracture. Journal of Camel Practice and Research. 2023; 30(3):331-335.

Cartiaux B, Amara A, Pailloux N, Paumier R, Malek A, Elmehatli K, Kachout S, Binsmida B, Montel C, Arribarat G and Mogicato G. Diffusion tensor imaging tractography in the one-humped camel (*Camelus dromedarius*) brain. Frontiers in Veterinary Science 10: Article number 1231421. 2023. DOI 10.3389/fvets.2023.1231421

Crijns CP, Gielen IM, van Bree HJ and Bergman EH. The use of CT and CT arthrography in diagnosing equine stifle

injury in a Rheinlander gelding. Equine Veterinary Journal. 2010; 42:367-371.

Cynthia MK. The Merck Veterinary Manual. 9th edition, Merck and Co, Inc. 2005; pp

Elemmawy YM, Abu-Seida AM, Senna NA and Yousef AF. MRI Features of fetlock and pastern regions in 30 chronically, un-treated lame draft horses confirmed by postmortem examination. International Journal of Veterinary Science. 2020; 9(2):217-223.

El-Gendy SAA, Kamal BM and Alsafy MAM. 3D render volume CT reconstruction of the bones and arteries of the hind digit of the dromedary camel (*Camelus dromedarius*). BMC Zoology. 2022; 7:49. doi. org/ 10. 1186/ s40850- 022- 00151-8.

El-Shafey A and Al-Galil A. Magnetic resonance imaging of the one-humped camel (*Camelus dromedarius*) digits. The Journal of American Science. 2012; 8(9):549-556.

El-Shafey A and Kassab A. Computed tomography and cross-sectional anatomy of the metatarsus and digits of the one-humped camel (*Camelus dromedarius*) and buffalo (*Bos bubalis*). Anatomia, Histologia, Embryologia. 2013; 42(2):130-137. doi: 10.1111/j.1439-0264.2012.01174.x.

El Nahas AE, Almohamad Z and Hagag U. Ultrasonography, computed tomography and magnetic resonance imaging of the dromedary camel distal limbs. BMC Veterinary Research. 2024; 20(1):Article number 12. DOI10.1186/s12917-023-03855-2

Emam H, Aref M, Abdelbaset-Ismail A, Gouda S and Gomaa M. Description of normal head structures of the one-humped camel (*Camelus dromedarius*) by magnetic resonance imaging, computed tomography and cross-sectional anatomy. Veterinary World. 2020; 13(8):1581-1587. DOI/10.14202/vetworld.2020.1581-1587

Fahmy LS, Zabady MK, Hegazy AA and Farag KA. Angular fetlock deformity of the hind limbs in camels: Clinical, radiological and histopathological studies. Scientific Journal of King Faisal University (Basic and Applied Sciences). 2006); 7:117-129.

FAO. Food and Agriculture Organisation of the United Nations. http.//faostat.fao.org/ 2009.

Gadallah SM, Sharshar AM, Elsharkawy SA and Fadel MS. Ultrasonographic description of tendons and ligaments at the palmar (plantar) aspect of the distal limb in the one humped camel (*Camelus dromedarius*). Australian Veterinary Journal. 2023; 101(10):397-408. doi: 10.1111/ avj.13268.

Gahlot TK. Selected Topics on Camelids. 1st Edn. Camel Publishing House, Bikaner, India. 2000; pp 378.

Gahlot TK. Proceedings of the International Camel Conference "Recent trends in camelids research and future strategies for saving camels", Rajasthan, India. 2007; pp 158-165.

Hagag U, Brehm W, Ramadan RO, Al Mubarak A, El Nahas A and Gerlach K. Normal radiographic and ultrasonographic appearance of the adult dromedary camel tarsus (one humped camel). Anatomia, Histologia, Embryologia. 2013; 42:344-354. doi: 10.1111/ ahe.12020.

Hassan MH and Abdelgalil AI. Ultrasonographic characteristics of the stifle joint in clinically normal donkeys (*Equus asinus*). International Journal of Veterinary Science. 2020; 9(2):254-258.doi:10.37422/IJVS/20.016

Hassan MH, El-Bably SH, El-Gammal SM and Abdelgalil AI. Ultrasound-guided brachial plexus block with mepivacaine in Zaraibi goats. International Journal of Veterinary Science. 2024; 13(4):447-452. https://doi. org/10.47278/journal.ijvs/2023.117

Ibrahim AH, Adam ZE and Tawfiek MG. Normal cross-sectional anatomy and magnetic resonance imaging of pastern and coffin joints in camel. Journal of Veterinary Medical Research. 2019; 26(2):271-279. DOI/10.21608/ JVMR.2019.67970

Janis CM, Theodor JM and Biosvert B. Locomotor evaluation in camels revisited: A quantitative analysis of pedal anatomy and the acquisition of the pacing gait. Journal of Vertebrate Paleontology. 2002; 22:110-121.

Kassab A. The normal anatomical, radiographical and ultrasonographic appearance of the carpal region of one-humped camel (*Camelus dromedarius*). Anatomia Histologia, Embryologia. 2008; 37(1):24-9. doi: 10.1111/j.1439-0264.2007.00790.x.

King FC, Aldarwich A, Hammoud M, Barigye R, Shawaf T, Al Aiyan A. Novel arthrocentesis approaches to the carpal joint of the dromedary camel (*Camelus dromedarius*). Scientific Reports. 2022; 12(1):12818. doi: 10.1038/ s41598-022-16801-3.

Levine DJ, Smith JJ, Richardson DW, Brown V, Beech J, Habecker P and Adam E. Suspected panosteitis in a camel. Journal of the American Veterinary Medical Association. 2007; 231(3):437-441. doi: 10.2460/ javma.231.3.437.

Mohamed AF. Fractures in single-humped camels: A retrospective study of 220 cases (2008–2009). Journal of King Abdulaziz University: Meteorology, Environment and Arid Land Agriculture Sciences. 2012; 23(1):3-17. DOI: 10.4197/Met. 23-1.1

Mostafa MB. Distal limb lameness in draught dromedary camels. Journal of Camel Practice and Research. 2020; 27(3):359-366. DOI/ 10.5958/2277-8934.2020.00052.1

Mostafa MB, Farag KA, Ragab GA and El Zomer ST. Arthrography of the interphalangeal joints in the camel (*Camelus dromedarius*). Camel Newsletter. 1993; (10): 20-27.

Puchalski SM. Advances in equine computed tomography and use of contrast media. Veterinary Clinic of North America: Equine Practice. 2012; 28:563-581.

Sharma NK and Sharma S. Grain founder in a male camel (*Camelus dromedarius*). Journal of Veterinary Science. 2006; 7(1):91-92.

Singh G and Gahlot TK. Foot disorders in camels (*Camelus dromedarius*). Journal of Camel Practice and Reearch. 1997; 4(2):145-154.

Squire KR and Boehm PN. External fixation repair of a displaced comminuted radial fracture in a juvenile camel. Journal of the American Veterinary Medical Association. 1991; 199(6):769-771.

DOI : 10.5958/2277-8934.2024.00003.1 *Vol 31 No 1, p 17-24*

FACTORS INFLUENCING THE PHYSICOCHEMICAL AND MINERAL COMPOSITION OF CAMEL MILK IN EASTERN ALGERIA

Meroua Kraimia[*1, 2], Abdelkader Adamou[1], Saliha Boudjenah-Haroun[3] and Mohammed Hocine Benaissa[4]

[1]Laboratory of Saharan Bioresources, Preservation and Valorisation Kasdi Merbah University, Faculty of Nature and Life Sciences - Ouargla, 30,000 Algeria

[2]Department of Veterinary Sciences, Faculty of Nature and Life, University of Eloued, 39,000, Algeria

[3]Research Laboratory on Phoeniciculture Kasdi Merbah University, Faculty of Nature and Life Sciences - Ouargla, 30,000 Algeria

[4]Scientific and Technical Research Centre for Arid Areas (CRSTRA), Nezla, Touggourt, Algeria

ABSTRACT

This study was conducted to evaluate the impact of lactation stage, season, number of births and the milking of the day on the chemical composition of camel milk in the Tebessa region (East Algeria). A total of 44 milk samples obtained from 10 healthy Saharawi camels were collected over the course of one year, divided into four seasons. The sampling occurred at various stages of lactation (the beginning, middle and end) and at parity numbers ranging from 1 to 8. The results of this study showed that fat, lactose, Zn and I were significantly ($P<0.05$) affected by the stage of lactation where the highest levels were recorded at the beginning of lactation and then gradually decreased until the end of lactation. Moreover, the majority of milk's physicochemical and mineral parameters were significantly influenced by the season where winter and autumn showed the highest mean values, whereas summer exhibited the lowest rates. Our research revealed a difference in the composition of morning and evening milk, particularly in terms of acidity D°, Fat g/l, Ca g/l, CL g/l and P g/l where the evening milk recorded the highest levels. On the other hand, no parity number impact on milk composition was detected. Our findings suggest that the stage of lactation during the season and the milking of the day have an impact on the composition of camel milk. These results could be taken into consideration when studying the improvement of the nutritional and technological aspects of milk.

Key words: Camel milk, dromedary camel, lactation stage, mineral composition, season

The dromedary camel is known to be able to live and produce in harsh conditions, enabling them to produce milk of high nutritional quality for longer durations compared to other species (Wernery, 2006; Patel *et al,* 2016). In Algeria, camel is a multipurpose animal used in protein production such as milk and meat and in transportation and tourism (Adamou and Boudjenah, 2012; Harek *et al,* 2022). Rural inhabitants living in the arid and semi-arid regions primarily depend on camel milk to fill the protein deficiency of animal sources (Faye *et al,* 2014). On the other hand, camel milk differs from milk of other dairy species by its nutritionally and medicinally important composition (Konuspayeva *et al,* 2007; Sboui *et al,* 2009). Indeed; since the literature has touted its curative and preventive therapeutic virtues (Sboui *et al,* 2016; Agrawal *et al,* 2005), there has been a surge in the interest of consumers from other non-desert regions for the purchase of camel milk. During the last decade, the situation started changing in the south of Algeria and many peri-urban camel dairy farms were established (Senoussi *et al,* 2023). The physicochemical properties of camel milk were reported to be influenced by many factors (Yoganandi *et al,* 2014a; Yoganandi *et al,* 2014b). Several studies have been carried out on the milk of dromedaries from Algeria, in particular on its physicochemical and biochemical composition (Siboukeur and Siboukeur, 2012), antimicrobial activity and the potentialities of its production (Adamou and Boudjenah, 2012). However, to our knowledge, studies on camel milk characteristics and factors influencing its composition in Algeria are very scarce. This study aims to evaluate the variations of the physicochemical composition and mineral milk of Saharawi camel in a steppe region according to the stage of lactation, season, number of parities on its composition.

Materials and Methods

Animals and Sampling

Our study focused on ten Sahrawi camels, all in excellent health and raised in an extensive manner.

SEND REPRINT REQUEST TO M KRAIMIA email: marouakraimia@gmail.com

These camels were at various stages of lactation (early, mid and late) and had between 1 and 8 births. Ranging in age from 4 to 15 years, these animals were part of a herd residing in the Ferkan commune within the Tebessa province, located in a steppe area of Algeria.

Forty samples were taken over the course of a year spread over four seasons (10 samples/season) were taken during the morning milking each season before leaving the herd, while in addition to the ten samples taken in the morning in the fall, we added four samples from the evening milking. The milk was immediately labeled, stored at 4°C and promptly transported to the laboratory. Further, information on the adopted livestock management and treated females was collected through a questionnaire.

Physicochemical, biochemical and mineral analysis

The milk quality analysis involved 18 parameters for each sample, resulting in a total of 792 data points over 44 samples. The pH values were detected using a pH meter (FE20, Mettler Toledo Technology Co., LTD, Shanghai, China). The titratable acidity was measured according to the Algerian Institute of Standardisation (IANOR) (NA 687-2011) by titrating the samples with 0.1 mol/L NaOH. Ash content was determined by incineration of the sample placed in the muffle furnace at 550 °C for 6 h (AOAC, 2000). Total dry extract (TDE) was determined by drying the sample in the oven at 103 ± 2°C for 24 hours and weighing the residue according to the method AOAC 926.08 (Association of Official Analytical Chemists, 1995). The milk fat content in all the milk samples were determined according to Gerber method (ISO 11870/ IDF 152:2009). The milk protein content of all the milk sample was determined using Kjeldahl method of nitrogen estimation as described in BIS Handbook. Density at 20°C was determined using a thermo-lactodensometer. lactose contents of milk samples were determined by the infrared spectrometric method (ISO, 2013), using a Bentley 150 instrument (Shimadzu, Model: 1800, Tokyo, Japan). To analyse the contents of different minerals (Na, k, Ca, Mg, Zn, Cu, I, Fe CL, P) flame atomic absorption spectrometry (A. Analyst 700, Perkin Elmer, USA) was used.

Statistical studies

The obtained results were statistically processed by the computer program MINITAB (version 19.0). Comparisons between the two variants were performed by ANOVA one way followed by HSD Tukey post Hoc test to estimate the significant differences at a 5% probability threshold.

Results and Discussion

Herd Characteristic

The owner concerned by the herd experience had inherited the profession from his grandparents, who were conventional breeders, raising diverse animals, including sheep, goats, horses, poultry and camels.

Feeding was based on the exploitation of natural rangelands that are characterised by their harshness and many constraints related to food, watering and climate. A supplement of concentrates for young animals was present, especially for those intended for slaughter. Moreover, watering was based on the installation of a well.

The size of the study herd consisted of 82 heads (2 males and 80 females) where 70% of it was composed of the Sahrawi breed and 30% of the Targui breed.

The use of milk from this herd remains within the family. The daily milk production was between 3 to 4 litres extract from 1 to 3 milkings per day, while lactation duration in general was between 8 months to a year, the dry-out period was 3 to 5 months and the average weaning age was 7 months for male and 12 months for female camels. Additionally, the gestation period was 12 months in each of the three farming systems. Calving intervals were about 25 months.

The process of reproduction followed natural breeding principles, which involved introducing camels, with limited interactions to females only during the breeding season.

Biochemical, mineral and physicochemical analysis of milk

Lactation stage effect

The obtained data regarding the effect of the lactation stage on the composition of camelina milk (Table 1) indicated the presence of a significant difference only for 4 parameters (fat, lactose, zinc and iodine). Importantly, milk fat was strongly influenced by the lactation stage where the highest rate in camels was recorded during the first three months of lactation (34.67±1.30g/l) compared to that obtained in the middle (27.40±5.69 g/l) and at the end (29.12±2.83 g/l). On the other hand, the lactose content was high in the first 6 months of lactation (42.5 g/l at the beginning) followed by a decrease

Table 1. Physical-chemical and mineral composition of raw milk according to lactation stage.

Physicochemical parameters		Lactation stage			
		Beginning	Middle	End	P
Physical analysis	pH	6.60 ±0.22	6.58±0.36	6.55±0.39	0.95
	Acidity(D°)	35.47±4.01	37.12±3.98	36.225±3.74	0.66
	Density	1.023±0.003	1.024±0.004	1.025±0.004	0.55
Chemical analysis	Ash (%)	7.22±0.63	7.53±0.47	7.61±0.46	0.26
	TDE (%)	11.81±1.68	11.64±0.22	12.23±0.98	0.51
	Protein(g/l)	29.95±2.26	31.30±1.51	30.59±3.06	0.47
	fat (g/l)	34.67± 1.30^{a}	27.40± 5.69^{b}	29.12±2.83^{b}	0.001
	Lactose(g/l)	42.49± 3.18^{a}	42.50± 2.81^{a}	38.35±4.07^{b}	0.02
Mineral analysis	Na (g/l)	0.432±0.017	0.442±0.074	0.410±0.058	0.44
	K (g/l)	2.63±0.19	2.35±0.23	2.37±0.13	0.94
	Ca (g/l)	1.51±0.35	1.67±0.16	1.75±0.17	0.12
	Mg (g/l)	0.073±0.0088	0.070±0.0041	0.074±0.0049	0.51
	Zn (g/l)	0.0048± 0.0004^{a}	0.0040±0.0006^{b}	0.0039±0.0005^{b}	0.005
	Cu (g/l)	0.0013±0.0002	0.0014±0.0002	0.0012±0.0002	0.14
	I (g/l)	0.145±0.023^{a}	0.137±0.019ab	0.117±0.009^{b}	0.02
	Fe (g/l)	0.0021±0.00026	0.0019±0.00035	0.0018±0.00038	0.20
	CL (g/l)	0.0013±0.00006	0.00126±0.00007	0.0013±0.0001	0.52
	P (g/l)	0.715±0.123	0.65±0.102	0.69±0.086	0.36

Different letters in the same line indicate a significant difference ($P \leq 0.05$)

Lactation stage : beginning: **birth- 3 months**/ middle: **3 months - 6 months**/ 6 months until the end of lactation

at the end of lactation (38.35±4.07 g/l). Moreover, a decrement was reported in zinc (0.0048±0.0004 at the beginning, 0.0040±0.0006 in the middle and 0.0039±0.0005 at the end) and iodine (0.145± 0.023; 0.137±0.019; 0.117±0.009), respectively.

In comparison with other studies; the lactation stage has a strong influence on the chemical composition of milk, particularly on the level of lactose, fat, protein, degreased dry extract, total dry extract, density and ash (Aljumaah *et al,* 2012; Musaad *et al,* 2013; Dowelmadina *et al,* 2014; Babiker and El-Zubeir, 2014; Nagy *et al,* 2017; Kadri *et al,* 2020). In contrast to the work of Guliye *et al* (2000) which indicated that the lactation stage did not affect camel milk composition.

The findings of our study are consistent with the research conducted by Zeleke (2007), Konuspayeva *et al* (2010), Aljumaah *et al* (2012) and Babiker and El-Zubeir s(2014). These studies reported that the levels of fat content, lactose, protein and total solids were higher during the first few months of lactation and then gradually decreased until the end of lactation; they interpreted it as due to the increase in the proportion of water in milk at the end of lactation. However, other studies reported higher fat content at the end of lactation (Kadri *et al,* 2020).

On the other hand; The decrement in lipid content likely reflects the typical malnutrition of desert habitat conditions (Abdalla *et al,* 2015); as well as the lack of nutritional supplementation (Dowelmadina *et al,* 2014).

If we consider lactose oxide content; it has been reported that it is the only element that remains almost unchanged during lactation (Farah *et al,* 2004; Haddadin *et al,* 2008). In contrast, studies conducted by Abdalla *et al* (2015) and Hadef *et al* (2018) revealed no significant variation in lactose content throughout the various stages of lactation. However, it can vary slightly depending on camel breeds in different parts of the world (Haj and Al Kanhal, 2010).

On the other hand; among the ten minerals investigated in this study, only zinc (Zn) and iodine (I) were affected by lactation displaying a significant difference and a gradual decrease throughout the lactation stages. In contrast, the levels of the remaining eight minerals (Na, k, Ca, Mg, Cu, Fe CL, P) remained stable from early to late lactation. In comparison with the work of Zhang *et al* (2005) and Aljumaah *et al* (2012); Na, K and Ca are significantly affected by the lactation stage, Na and K levels are relatively low at the beginning and then rise gradually throughout lactation.

The Ca content was found low during the first day of lactation, then it increased slightly until the 7th day and it gradually decreased until the 90th day, as well as the level of P. In addition; a large variation was noted in Cl content throughout the lactation period (Zhang *et al,* 2005). By contrast; Aljumaah *et al* (2012) reports that the highest Ca content is recorded in mid-lactation.

Variations in the main mineral contents of camel milk were attributed to racial differences, diet, lactation stage, drought conditions or analytical procedures (Farah, 1993; Mehaia *et al,* 1995), health status (Farah, 1996) and water consumption (Haddadin *et al,* 2008).

Season effect

The data presented in Table 2 revealed that the physicochemical and mineral composition of camel milk were highly significant ($p < 0.001$) depending on the season. Indeed; The pH value was very low in winter (6.33±0.09) then it increased gradually to reach its maximum in summer at 6.88±0.30 then fell again to 6.65±0.29 in autumn.

Nevertheless, a large variation was observed regarding the acidity value, where the highest levels were recorded in autumn and summer (40.97±4.39D°) while the lowest was in spring (33.02±3.33D°). However, the density remained stable for three seasons at a value of 1.026 and then decreased slightly in winter to 1.020. On the contrary, the highest MS value was recorded in winter and spring at 12% compared to the other two seasons. Additionally, the protein content showed a remarkable variation with the season with the highest content recorded in winter (32.76±1.09g/ l) and the lowest in autumn and spring. Meanwhile, the low lactose content was marked only in summer at 38.25±3.94g/l.

Furthermore, Na concentration reached its peak in autumn at 0.512 ± 0.060g/l and its minimum in spring at 0.392 ± 0.043g/l. In contrast, Ca appears in low value across three seasons but showed a significant increase in spring (1.90±0.02g/l). Similarly, Mg had its highest value (0.0837±0.0055g/l), while exhibiting a decrease only in spring at 0.0036±0.0005, contrasting with calcium. Also, a slight variation in the Cl rate was detected and correlated to the season changes.

On the other hand, the mineral content of K, Cu, Fe and P in addition to ash and fat, were not affected by the season.

The results of our study revealed that the mean values of the majority of the chemical and mineral components of milk (TDE, protein, lactose, Na, Mg and Zn) were elevated in winter and autumn while

Table 2. Biochemical and mineral physicochemical composition of raw milk according to season.

Physicochemical parameters		Season				
		Winter	Spring	Summer	Fall	P
Physical analysis	pH	6.33±0.09^{c}	6.51±0.14^{bc}	6.88±0.30^{a}	6.65±0.29^{ab}	0.0001
	Acidity (D°)	36.27±1.30b^{c}	33.02±3.33^{c}	39.52±2.59^{ab}	40.97±4.39^{a}	0.000 3
	Density	1.020 ±0.0005^{bc}	1.026±0.0012^{a}	1.026±0.0042^{a}	1.020±0.0024^{a}	0.0003
Chemical analysis	Ash (%)	7.55±0.40	7.38±0.23	7.42±0.84	7.6±0.76	0.84
	TDE (%)	12.23±1.03^{a}	12.38± 0.79^{a}	11.07±1.00^{ab}	11.94±0.68^{b}	0.01
	Protein (g/l)	32.76±1.09^{a}	28.8±1.91^{b}	30.27±1.54^{ab}	27.42±5.03^{b}	0.002
	fat (g/l)	33.17±1.89	29.32±4.33	28.7±6.52	30.57±4.07	0.17
	Lactose (g/l)	41.72± 2.75^{ab}	43.37±2.94^{a}	38.25±3.94^{b}	41.32±1.74^{ab}	0.007
Mineral analysis	Na (g/l)	0.455± 0.078^{ab}	0.392±0.043^{b}	0.447±0.038^{ab}	0.515±0.060^{a}	0.001
	K (g/l)	2.26±0.15	2.44±0.19	2.38±0.13	2.28±0.21	0.43
	Ca (g/l)	1.48±0.28^{a}	1.90±0.02^{b}	1.55±0.09^{a}	1.61±0.14^{a}	0.000 4
	Mg (g/l)	0.0705±0.0037^{b}	0.0710±0.0041^{b}	0.0765±0.0081^{b}	0.0837±0.0055^{a}	0.0005
	Zn (g/l)	0.0044±0.0004^{a}	0.0036±0.0005^{b}	0.0046±0.0004^{a}	0.005±0.0007^{a}	0.000 1
	Cu (g/l)	0.0014±0.0002	0.0013±0.0002	0.0012±0.0002	0.0012±0.0002	0.22
	I (g/l)	0.122±0.018^{b}	0.125±0.013^{b}	0.152±0.017^{a}	0.13±0.021^{ab}	0.004
	Fe (g/l)	0.0017±0.0005	0.0020±0.0001	0.0020±0.0001	0.0021±0.0001	0.06
	CL (g/l)	0.0012±0.00006^{b}	0.0013±0.00004^{a}	0.0012±0.00006^{b}	0.0013±0.00002^{a}	0.0003
	P (g/l)	0.66±0.16	0.70±0.04	0.68±0.07	0.77±0.03	0.08

Different letters in the same line indicate a significant difference ($P \leq 0.05$).

the lowest levels were recorded in summer. These results are consistent with those reported by Nagy *et al* (2017) for Fat, Protein, TDE and ash and by Musaad *et al* (2013) for fat, protein and lactose. This could be explained by the better availability of quality food and water during the wet months compared to the dry months.

In parallel, Haddadin *et al* (2008), Shuiep *et al* (2008) and Hamed *et al* (2017) recorded a minimum fat content in camel milk during the warm season. While, protein and lactose recorded their minimum levels in autumn, which is in contrast to the Fat rate which was at its peak in the summer period according to Bakheit *et al* (2008) diverging from the findings of our study where the fat rate remained stable throughout the year. All these variations could be explained by seasonal changes that affect food quality because total energy intake is directly related to fat content (Shuiep *et al,* 2008), as well as the state of hydration of camels during the summer (Yagil, 1982).

Our results are in concordance with those reported by Hamed *et al* (2017) suggesting that the ash content was not influenced by the season and close to that observed by Zhang *et al* (2005) on the Bactrian camel and by Musaad *et al* (2013) indicating that the ash rate is relatively stable throughout the year, with a slight decrease in autumn.

In the same line, TDE, pH and Cl values were not affected by the season (P > 0.05) according to Bakheit *et al* (2008) and Hamed *et al* (2017), respectively.

On the other hand, the ash content, K, Cu, Fe and P were slightly varying throughout the year, with the exception of Ca which rose only during the spring.

In addition, regarding minerals Hamed *et al* (2017) demonstrated variations in the average amounts of K, Ca, Na and Mg, the first two being high during the rainy season, while the last two were during the dry season and these variations may be due to a dilution effect. Furthermore, Guler (2007) concluded that these changes were likely related to animal feeding behaviour and changes in pasture composition.

Parity effect

Statistical analysis of the data mentioned in Table 3 we noted that the physicochemical and mineral composition of camels' milk was not significantly affected by parity (p <0.05).

Table 3. Physicochemical and mineral composition of raw milk according to parity number.

Physicochemical parameters		Number of parity			
		1st lactation	2nd to 6th lactation	> 6th lactation	P
Physical analysis	pH	6.28±0.06	6.28±0.15	6.26	0.98
	Acidity(D°)	39.86±5.95	39.65±4.35	55.9	0.08
	Density	1.02±0.005	1.11±0.10	1,029	0.33
Chemical analysis	Ash (%)	7.41±0.47	7.13±0.70	7.11	0.83
	TSM (%)	11.90±0.33	12.64±0.94	11.33	0.29
	Protein(g/l)	31.45±0.80	30.85±1.24	30.1	0.89
	fat (g/l)	35.43±2.21	31.92±1.48	30.2	0.07
	Lactose(g/l)	43.46±1.42	43.82±5.03	45.7	0.88
Mineral analysis	Na (g/l)	0.493±0.02	0.462±0.08	0.44	0.73
	K (g/l)	2.28±0.18	2.19±0.09	2.40	0.39
	Ca (g/l)	1.67±0.02	1.48±0.29	1.66	0.56
	Mg (g/l)	0.070±0.001	0.071±0.04	0.079	0.14
	Zn (g/l)	0.0045±0.0004	0.0040±0.0005	0.0042	0.71
	Cu (g/l)	0.0015±0.0002	0.00013±0.00009	0.0013	0.33
	I (g/l)	0.126±0.02	0.117±0.009	0.11	0.60
	Fe (g/l)	0.0016±0.0003	0.0017±0.0005	0.0013	0.63
	CL (g/l)	0.0012±0.00006	0.0012±0.00004	0.0012	0.98
	P (g/l)	0.63±0.14	0.78±0.10	0.66	0.31

Different letters in the same line indicate a significant difference (P ≤ 0.05)
(One parity: 3 camels, 2-6 parities: 4 camels, more than 6 parities: 1 camels)

The findings of this study are consistent with those of Musaad *et al* (2013); Abdelgadir (2018) and Kadri *et al* (2020) who stated that parity had no effect on milk quality parameters. In contrast to the other studies, parity had a significant effect ($P < 0.001$) on all milk parameters analysed by Nagy *et al* (2017) according to which; the milk chemical composition of primiparous dromedaries was superior to that of multiparous.

Zeleke (2007) demonstrated that milk components are at their maximum values in the third lactation and the minimum values in the first and sixth lactation. Likewise, Aljumaah *et al* (2012) found that the highest mean values were recorded in the first lactation and then gradually decreased thereafter; however, the fat composition of milk as well as some minerals (Ca, Na) have not changed with parity.

The absence of significant differences between lactation ranks on all milk parameters may be attributed to the small number of experienced camels.

Effect of day milking (morning and evening milking)

The effect of milking time on milk composition was evaluated using four dairy camels. Milk samples were collected from each lactating camel from morning and evening milking and taken for the determination of composition and physical characteristics of milk. Indeed, the data mentioned in Table 4 reported the presence of significant differences between the composition of milk collected in the morning and that collected in the evening. However, the acidity content, Fat, Cl and P were higher in evening milk than in morning milk, reaching 40.22±2.34D°, 36.12±2.38g/l, 0.0014±0.00001g/l, 0.83±0.01g/l, respectively, but exactly the opposite for the Ca content which decreases in the evening.

Our results concerning the effect of morning and evening milking on milk composition showed in general that the component content of milk is higher during evening milking in comparison to the morning. These results are consistent with the studies of Nagy *et al* (2017) indicating that the fat and TDM content was significantly important in afternoon milk ($P < 0.001$), on the other hand, lactose was more elevated in the morning and the protein content remained constant in both milkings times. These authors reported no increase in daily milk production when camels with high productivity were milked three times daily, in comparison to those milked twice a day. They propose that increasing the milking frequency might not enhance milk production for this particular species. This is contrary to what was shown by Faye in 2008, according to which three milkings can increase daily production to 28%.

In addition, Alshaikh and Salah (1994) and Ayadi *et al* (2009) reported that the rate of milk

Table 4. comparison of the physicochemical, biochemical and mineral composition of morning and evening milk.

Physicochemical parameters		Morning	Evening	P
Physical analysis	pH	6.51±0.12	6.52±0.07	0.88
	Acidity D°	33.05±2.89^{b}	40.22±2.34^{a}	0.01
	Density	1.02±0.001	1.02±0.001	0.82
Chemical analysis	Ash (%)	7.38±0.20	7.69±0.20	0.11
	TDE (%)	12.38±0.68	12.27±0.70	0.85
	MP (g/l)	28.80±1.66	28.85±1.51	0.97
	fat (g/l)	29.32± 3.75^{b}	36.12±2.38^{a}	0.03
	Lactose (g/l)	43.55±2.34	43.57±2.18	0.98
Chemical analysis	Na (g/l)	0.392±0.04	0.450±0.03	0.08
	K (g/l)	2.44±0.17	2.39±0.16	0.71
	Ca (g/l)	1.90± 0.018^{a}	1.73±0.12^{b}	0.03
	Mg (g/l)	0.071±0.003	0.069±0.003	0.49
	Zn (g/l)	0.003±0.0004	0.003±0.0003	0.63
	Cu (g/l)	0.0013±0.0001	0.0013±0.0001	0.5
	I (g/l)	0.0125±0.011	0.125±0.011	1
	Fe (g/l)	0.0020±0.001	0.0022±0.003	0.46
	CL (g/l)	0.0013±0.00004	0.0014±0.00001	0.02
	P (g/l)	0.70±0.40^{b}	0.83±0.01^{a}	0.002

Different letters in the same line indicate a significant difference ($P \leq 0.05$).

secretion decreased with increasing milking intervals as well as for the rate of organic constituents (lactose, SNF, fat and protein) and inorganic milk (sodium, potassium, calcium and magnesium).

However, several components of the milk treated in this study were not affected by morning and evening milking for pH, density, protein, lactose and most minerals except for the Ca level that rises in evening milking. These results are consistent with the results obtained by Ayadi *et al* (2009) who observed that protein, lactose, density and ash values remained constant for all milking intervals. While the K, Ca and Mg content of milk increased with the interval between milkings. It will be very interesting to do further studies in order to explore in depth the consequences of this difference.

Conclusion

In conclusion, the present study confirmed that the physicochemical and mineral composition of camel milk could be influenced by several factors such as lactation stage, season and day milking. Our data reported no impact of Number of births. Forward research on breed effect, husbandry practice, feeding conditions, geographic location and production system on more animals is essential for a more comprehensive evaluation of management factors. On this basis, we can improve Algerian camel breeding, relying on them as valuable contributors to milk production and their active participation in boosting the country's economy.

Conflicts of Interest

The authors declare no conflict of interest.

References

Abdalla EB, Ashmawy AEHA, Farouk MH, Salama OAER, Khalil FA and Seioudy AF. Milk production potential in Maghrebi she-camels. Small Ruminant Research. 2015; 123:129-135.

Abdelgadir AMM. Measurements of Milk Flow and Udder Morphology and Their Impact on Milkability and Selecting of Dairy Camels (*Camelus dromedarius*) Under Intensive System. Sudan University of Science and Technology. 2018.

Adamou A and Boudjenah S. Potentialités laitières chez la chamelle Sahraoui dans la région du Souf. Annals of Science and Technology. 2012; 4:7-7.

Agrawal R, Sahani M, Tuteja F, Ghouri S, Sena D, Gupta R and Kochar D. Hypoglycemic activity of camel milk in chemically pancreatectomised rats-an experimental study. International Journal of Diabetes in Developing Countries. 2005; 25:75-79.

Aljumaah RS, Almutairi FF, Ismail E, Alshaikh MA, Sami A and Ayadi M. Effects of production system, breed, parity and stage of lactation on milk composition of dromedary camels in Saudi Arabia. Journal of Animal and Veterinary Advances. 2012; 11:141-147.

Alshaikh MA and Salah MS. Effect of milking interval on secretion rate and composition of camel milk in late lactation. Journal of Dairy Research.1994; 61:451-456.

AOAC, Official methods of analysis of AOAC International, 17th Ed., AOAC International, Gaithersburg, MD, USA, 2000.

Ayadi M, Hammadi M, Khorchani T, Barmat A, Atigui M and Caja G. Effects of milking interval and cisternal udder evaluation in Tunisian Maghrebi dairy dromedaries (*Camelus dromedarius L.*). Journal of Dairy Science. 2009; 92(4):1452-1459.

Babiker WI and El-Zubeir IE. Impact of husbandry, stages of lactation and parity number on milk yield and chemical composition of dromedary camel milk. Emirates Journal of Food and Agriculture. 2014; pp 333-341.

Bakheit SA, Majid A. M and Nikhala, A. Camels (*Camelus dromedarius*) under pastoral systems in North Kordofan, Sudan: Seasonal and parity effects on milk composition. Journal of Camelid Science. 2008; 1, 32-36.

Dowelmadina I, El-Zubeir I, Salim A and Arabi, O.. Influence of some factors on composition of dromedary camel milk in Sudan. Global Journal of Animal Scientific Research. 2014; 2:120-126.

Farah K, Nyariki D, Ngugi R, Noor, I and Guliye A. The Somali and the camel: Ecology, management and economics. The Anthropologist. 2004; 6:45-55.

Farah Z. Composition and characteristics of camel milk. Journal of Dairy Research. 1993; 60:603-626.

Farah Z. Camel milk properties and products: Swiss Centre for Development Cooperation in Technology and Management. 1996.

Faye B. Potentiel de productivité laitière des chameaux. ICAR TechnicalSeries Dans : Cardellion, R, Rosati, A. et Mosconi, C. (eds) État actuel des ressources génétiques, systèmes d'enregistrement et de production chez les camélidés africains, asiatiques et américains, No. 11, Actes du Séminaire ICAR/ FAO, Sousse, Tunisie, 30 mai 2004. ICAR, Rome, Italie. 2008; pp 93-104.

Faye B, Jaouad M, Bhrawi K, Senoussi A, Bengoumi M.,. Elevage camelin en Afrique du Nord: ´etat des lieux et perspectives; Camel farming in North Africa: current state and prospects; Cría de cam´elidos en ´Africa del Norte: situaci´on actual y perspectivas. Revue D'élevage et de Médecine Vétérinaire Des Pays Tropicaux. 2014; 67:213–221.

Güler, Z. Levels of 24 minerals in local goat milk, its strained yoghurt and salted yoghurt (tuzlu yoğurt). Small Ruminant Research, 2007; 71:130-137.

Guliye, A, Yagil, R, & Deb, F. Milk composition of Bedouin camels under semi-nomadic production system. Journal of Camel Practice and Research. 2000; 7(2):209-212.

Haddadin MS, Gammoh SI and Robinson RK. Seasonal variations in the chemical composition of camel milk in Jordan. Journal of Dairy Research. 2008; 75:8-12.

Hadef L, Aggad H, Hamad B and Saied M. Study of yield and composition of camel milk in Algeria. Scientific

Study & Research. Chemistry & Chemical Engineering, Biotechnology, Food Industry. 2018; 19:1-11.

Haj OA and Al Kanhal Hamad A. Compositional, technological and nutritional aspects of dromedary camel milk. International Dairy Journal. 2010; 20:811-821.

Hamed H, El Feki A and Gargouri A. Influence of wet and dry season on milk composition of dromedary camels (*Camelus dromedarius*) from Tunisia. Iranian Journal of Applied Animal Science. 2017; 7:163-167.

Harek D, Ikhlef H, Bouhadad R, Sahel H, Djellout N and Arbouche F. Gene-driving management practices in the dromedary husbandry systems under arid climatic conditions in Algeria. Pastoralism. 2022; 12(1):1-12.

ISO. International Standard Organisation: Standard ISO 9622:2013 (IDF 141:2013), ISO Central Secretariat, Geneva Switzerland, 2013.

Kadri S, Adamou A, Boudjenah-Haroun S and Baameur M. Effets du génotype, de la parité et du stade de lactation sur la composition du lait de dromadaire au Sud-Est Algérien. Livestock Research for Rural Development. 2020; 32(10).

Kjeldahl J. Determination of protein nitrogen in food products. Encyc. Food Agric. 1983; 28:757-765.

Konuspayeva G, Faye B, Loiseau G and Levieux D. Lactoferrin and immunoglobulin contents in camel's milk (*Camelus bactrianus, Campus dromedarius* and *Hybrids*) from Kazakhstan. Journal of Dairy Science. 2007; 90:38-46. https://doi. org/10.3168/jds.S0022-0302(07)72606-1.

Konuspayeva G, Faye B, Loiseau G, Narmuratova M, Ivashchenko A, Meldebekova A and Davletov S. Physiological change in camel milk composition (*Camelus dromedarius*) 1. Effect of lactation stage. Tropical Animal Health and Production. 2010; 42(3): 495-499.

Mehaia MA, Hablas MA, Abdel-Rahman KM and El-Mougy SA. Milk composition of majaheim, wadah and hamra camels in Saudi Arabia. Food Chemistry. 1995; 52: 115-122.

Musaad AM, Faye B and Al-Mutairi SE. Seasonal and physiological variation of gross composition of camel milk in Saudi Arabia. Emirates Journal of Food and Agriculture, 2013; 618-624.

Nagy P, Fábri ZN, Varga L, Reiczigel J and Juhász J. Effect of genetic and nongenetic factors on chemical composition of individual milk samples from dromedary camels (*Camelus dromedarius*) under intensive management. Journal of Dairy Science. 2017; 100:8680-8693.

Patel AS, Patel SJ, Patel NR and Chaudhary GV. Importance of camel milk-An alternative dairy food. Journal of Livestock Science. 2016; 7(1):19-25.

Sboui A, Djegham M, Belhadj O and Khorchani T. Le lait de chamelle: qualités nutritives et effet sur les variations de la glycémie. Options Méditerranéennes, A 2016; 115:487-492.

Sboui A, Khorchani T, Djegham M and Belhadj O. Comparaison de la composition physicochimique du lait camelin et bovin du Sud tunisien; variation du pH et de l'acidité à différentes températures. Afrique Science: Revue Internationale Des Sciences Et Technologie. 2009; 5(2).

Senoussi, A, Abazi, A, Bezziou, S and Brahimi, Z., March). The Camel in Algeria: Animal of the Past, Present and Future: What Is the Scope of Farming Systems?. In Biology and Life Sciences Forum. 2023; 22:1-3.

Shuiep, E, El Zubeir, I, El Owni, O and Musa, H. Influence of season and management on composition of raw camel (*Camelus dromedarius*) milk in Khartoum state, Sudan. Tropical and Subtropical Agroecosystems. 2008; 8:101-106.

Siboukeur A and Siboukeur O. Caractéristiques physico-chimiques et biochimiques du lait de chamelle collecté localement en comparaison avec le lait bovin. Annals of Science and Technology. 2012; 4:6-6.

Wernery U. Camel milk, the white gold of the desert. Journal of Camel Practice and Research. 2006: 13(1):15-26.

Yagil R. Camels and camel milk (FAO animal production and health paper). FAO (Food and Agriculture Organisation of the United Nations). [Google Scholar] 1982.

Yoganandi J, Mehta BM, Wadhwani KN, Darji VB and Aparnathi KD. Comparison of physico-chemical properties of camel milk with cow milk and buffalo milk. Journal of Camel Practice and Research. 2014a; 21(2):253-258.

Yoganandi J, Mehta BM, Wadhwani KN, Darji VB and Aparnathi KD. Evaluation and comparison of camel milk with cow milk and buffalo milk for gross composition. Journal of Camel Practice and Research. 2014b; 21(2):259-265.

Zeleke Z. Non-genetic factors affecting milk yield and milk composition of traditionally managed camels (*Camelus dromedarius*) in Eastern Ethiopia. Parity. 2007; 1, 97.

Zhang H, Yao J, Zhao D, Li, H, Li J and Guo M. Changes in chemical composition of Alxa Bactrian camel milk during lactation. Journal of Dairy Science. 2005; 88:3402-3410.

DOI : 10.5958/2277-8934.2024.00004.3 *Vol 31 No 1, p 25-28*

LACTATION RELATED CHANGES OF HAEMATOLOGICAL PARAMETERS OF FEMALE DROMEDARY CAMELS REARED UNDER SEMI-INTENSIVE FARMING SYSTEM IN ALGERIAN EXTREME ARID REGION

Maria Chikha[1], Tarek Khenenou[1], Djalel Eddine Gherissi[2], Rabah Mayouf[3], Djallal Eddine Rahmoun[2], Naif Al-Gabri[4,5], Nacira Ramdani[6], Anas Ayyad Abu-Sulik[7], Hafiza Aidoudi[1] and Sabry Mohamed El-Bahr[8,9]

[1]Laboratory of Science and Techniques for Living, Institute of Agricultural Sciences and Veterinary Sciences, Mohamed-Cherif Messaadia University - Souk Ahras, BP 41000 Souk-Ahras, Algeria

[2]Laboratory of Animal Production, Biotechnologies and Health, Institute of Agricultural Sciences and Veterinary Sciences, Mohamed-Cherif Messaadia University - Souk Ahras, BP 41000 Souk-Ahras, Algeria

[3]Faculty of Biology, Echahid Hamma Lakhdar University, The new group BP 789, 39000 El Oued, Algeria

[4]Department of Pathology, Faculty of Veterinary Medicine, Thamar University, Yemen

[5]Laboratory of Salam Veterinary group, Al-Qassim, 51911 Buraydah, Saudi Arabia

[6]National Institute of Veterinary Medicine, 16000 Algiers, Algeria

[7]Faculty of Medicine, Jordan University of Science and Technology, P.O.Box 3030, 22110 Irbid, Jordan

[8]Department of Biomedical Sciences, College of Veterinary Medicine, King Faisal University, 31982 Al-Ahsa, Saudi Arabia

[9]Department of Biochemistry, Faculty of Veterinary Medicine, Alexandria University, 21526 Alexandria, Egypt

ABSTRACT

Thirteen female camels were used in this study to investigate the changes in some haematological parameters during the different stages of lactation including early lactation, mid-lactation and the last stage of lactation. A significant decrease (P<0.001) in mid and late lactation, compared to early lactation was recorded for the following parameters: number of white blood cells, number of lymphocytes, number of monocytes, number of granulocytes, per cent ratio of lymphocytes and mean corpuscular volume. While, the levels of per cent ratio of monocytes, per cent ratio of granulocytes, red blood cells and haematocrit were low in early lactation then showed a significant raise in mid and late lactation (P<0.001). Moreover, The levels of mean corpuscular haemoglobin and mean corpuscular haemoglobin concentration were high during early lactation, then significantly decreased (P<0.001) in mid-lactation and then increased in late lactation. No significant difference was observed in mean corpuscular volume and haemoglobin concentration between early and mid-lactation. There was no significant difference in the number of platelets (p> 0.05). The current study gives baseline data about the value change of the main haematological parameters during lactation in female camels in the Algerian desert and these results could be used as a database for the diagnosis of different disorders and also for upcoming research in camels.

Key words: Camel, blood analysis, haematology, lactation, physiology

Blood metabolites are utilised 80% by the secretory cells of the mammary gland for milk synthesis during lactation (Piccione *et al,* 2009). About 500 litre of blood circulate to produce one litre of milk (Braun and Forster, 2012). In dairy animal, pregnancy and lactation are considered as the two most critical stages which affect the haematological and the biochemical profile of the blood (Krajnicakova *et al,* 1993; Iriadam, 2007; Das *et al,* 2016).

In dromedary camel, few authors, have studied the haematological profiles during lactation stages and others studied it during postpartum period (Hussein *et al,* 1992; El-Zahar *et al,* 2017; El-Sayed, 2020). However, the change of haematological parameters during lactation in female camels reared under extreme arid condition of the Algeria Sahara is least studied. This study was therefore, planned to evaluate the physiological changes of some haematological parameters during different stages of lactation in camels of Algeria Sahara in extreme conditions.

SEND REPRINT REQUEST TO MARIA CHIKHA email: m.chikha@univ-soukahras.dz

Materials and Methods

Studied animals

In the current study, thirteen multiparous female dromedary camels aged 8-12 years were used. Animals were housed in a semi-intensive breeding system in El Oued region, located in the southeast of Algeria. These were apparently healthy and kept in the same nutritional and environmental conditions. The camels were housed in an open stall in the desert, far away from any residential buildings and roads. These were milked in early morning and later, these were sent for grazing in a natural desert pasture. They returned back in the middle of day and were separated from their calves. They were supplied by Alfalfa (*Medicago sativa L.*) and a mix of barley (*Hordeum vulgare*), white bran, wheat flour and olive pomace pellets in the morning. All camels had normal parturition.

Blood collection and analysis

During this study, blood samples for 13 female camels were collected in morning at each stages of lactation, i.e. first months of lactation (15 days post-calving), mid-lactation at the fifth months of lactation (150 days post-calving) and the last stage of lactation (300 days post-calving). Afterwards, samples were kept in cold packs and transported to the laboratory for haematological analyses. Haematology auto analyser MINDRAY (BC-3000Plus, China) was used for determination of white blood cells (WBC), lymphocyte (LYM), number of monocyte (MON), number of granulocyte (GRAN), per cent ratio of lymphocyte (LYM %), per cent ratio of monocyte (MON%), per cent ratio of granulocyte (GRAN%), number of red blood cells (RBC), haemoglobin concentration (HGB), haematocrit (HCT), mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH), mean corpuscular haemoglobin concentration (MCHC), number of platelets (PLT) and mean platelet volume (MPV).

Statistical analysis

The data of haematological parameters were analysed by IBM SPSS Statistics, version 25.0, Armonk, NY, USA. The results were presented as mean values ± standard Deviation (SD).To compare multiple measures during the different stages of lactation, repeated measures ANOVA were used. To verify data distribution, the Kolmogorov–Smirnov test was used. Bonferroni multiple comparison test was used as a Post Hoc Tests. The level of significance was set at $p<0.05$.

Results and Discussion

The results of white blood cell and red blood cell and platelet parameters are summarised in table 1 and table 2, respectively. As shown in table 1, there was a significant difference in WBC during the different stages of lactation, where a high level was observed in the first stage of lactation. Similar results had been obtained in camels (Hussein *et al,* 1992) and in jennies (Bonelli *et al,* 2016) except for the value of WBC which was higher in our study in the first stage of lactation ($54.08\pm25.28\times10^9$/L) when compared with that obtained by Hussein *et al* (1992) ($6.6\pm1.0\times10^9$/L) and Bonelli *et al* (2016) (10.9±0.8 K/mL). This difference might be attributed to the difference of breeding and/or feeding system. However, no significant difference in WBC were reported during the different stages of lactation in Baladi goats (Azab and Hussein, 1999), cows (Coroian *et al,* 2017) and Mehshani buffaloes (Das *et al,* 2016). There was a significant difference in the number of lymphocyte in animals of present study, similar results were reported by Hussein *et al* (1992) and El-Sayed (2020) in camels during lactation. However, no significant difference had been detected during post-partum period in camels (El-Zahar *et al,* 2017) and Baladi goats (Azab and Hussein, 1999).

There was a significant change in the percentage of lymphocytes during lactation, however, these changes were not observed earlier in camels (El-Zahar *et al,* 2017) and in Baladi goats (Azab *et al,* 1999) during postpartum period and in Mehshani buffaloes (Das *et al,* 2016) during the different stages of lactation. In the current study, a high number of monocytes was observed in the first stage of lactation. Parallel to the current findings, Hussein *et al* (1992) and El-Sayed (2020) reported a significant difference in the number of monocyte during lactation in camels. The current study indicated a significant change in the percentage of monocyte during lactation, however, previous studies did not find significant difference during postpartum period in camels (El-Zahar *et al,* 2017), Baladi goats (Azab and Hussein, 1999) and Mehshani buffaloes (Das *et al,* 2016) during different stages of lactation. The current study reported that there were a significant difference during lactation in the number of granulocyte, however, Hussein *et al* (1992) found a significant difference in neutrophils and not in eosinophils during lactation in camels. The current study reported that there was a significant change in the percentage of granulocytes during lactation, however, no significant difference was observed during postpartum period in camels (El-Zahar *et al,* 2017) and in Mehshani buffaloes (Das *et al,* 2016) during the different stages of lactation. In Baladi goats, a significant difference in the percentage

of eosinophils along with insignificant difference in the percentage of neutrophils and basophils were observed (Azab and Hussein, 1999). The significant increase in white blood cell, lymphocytes, monocytes, granulocytes and the percentage of lymphocytes in the first stage of lactation is probably due to the physiological change from pregnancy to lactation and the high milk production in this period.

As shown in table 2, there was a significant difference during lactation in red blood cells. Similar results were reported in camels (Hussein *et al,* 1992), jennies (Bonelli *et al,* 2016) and Baladi goats (Azab and Hussein, 1999). However, other researchers didn't observe any difference during post-partum period in camels (El-Zahar *et al,* 2017) and Mehshani buffaloes (Das *et al,* 2016). The low value at the first stage of lactation could be due to the effects of the residual of late gestation and also due to a rise of milk production demand (Hussein *et al,* 1992). In the current study, a low value of haemoglobin in the first and mid stage of lactation was reported, then the haemoglobin was significantly increased in the last stage of lactation. In accordance with the current findings, a significant effect of lactation in haemoglobin was observed in camels (El-Sayed, 2020) and Baladi goats (Azab and Hussein, 1999), however, Azab and Hussein (1999) reported a significant decrease in haemoglobin during long lactation. Contrarily, no significant difference were observed during lactation in camels (Hussein *et al,* 1992), in Jennies (Bonelli *et al,* 2016) and Mehshani buffaloes (Das *et al,* 2016; Hagawane *et al,* 2009).

In agreement with the current findings, a significant difference of haematocrit during the different stages of lactation and post-partum period was also observed in Jennies (Bonelli *et al,* 2016) and Baladi goats (Azab and Hussein, 1999). However, no significant difference of haematocrit was observed during lactation in camels (El-Zahar *et al,* 2017; Hussein *et al,* 1992) and Mehshani buffaloes (Das *et al,* 2016; Hagawane *et al,* 2009). The lower HCT value during the first stage of lactation as reported in the current study which could be due to a high

Table 1. White blood cell parameters values in 13 female camels during lactation period (early, mid, late).

Parameters	Stage of lactation			P value
	Early lactation (n=13)	Mid-lactation (n=13)	Later lactation (n=13)	
WBC ($\times10^9$/L)	54.08±25.28^a	10.63±1.71^b	11.41±2.86^b	0.000
LYM ($\times10^9$/L)	37.97±21.93^a	1.83±0.63^b	1.51±0.70^b	0.000
MON ($\times10^9$/L)	4.43±2.46^a	1.47±0.66^b	1.45±0.54^b	0.000
GRAN($\times10^9$/L)	12.43±3.78^a	7.33±1.66^b	8.44±2.26^b	0.000
LYM%	66.86±13.01^a	17.52±7.50^b	13.05±4.56^c	0.000
MON%	7.86±2.61^a	14.09±6.08^b	12.95±4.98^b	0.000
GRAN%	25.27±11.96^a	68.38±9.62^b	73.99±7.37^b	0.000

a,b,c; Means within a column with different superscripts differ significantly ($p<0.05$). WBC; Number of white blood cells, LYM; Lymphocyte, MON; Monocyte, GRAN; Granulocyte, LYM; % Percent Ratio of Lymphocyte, MON%; Per cent Ratio of Monocyte, GRAN%; Percent ratio of Granulocyte.

Table 2. Red blood cell and platelets parameters value in 13 female camels during lactation period (early, mid, late).

Parameters	Stage of lactation			P value
	Early lactation (n=13)	Mid-lactation (n=13)	Later lactation (n=13)	
HGB (g/dl)	12.42±1.00^{ab}	12.39±1.70^a	13.90±1.64^b	0.013
RBC ($\times10^{12}$/L)	4.27±0.66^a	5.33±0.65^b	5.35±0.53^b	0.000
HCT%	18.33±2.43^a	22.98±2.82^b	22.48±2.02^b	0.000
MCV fL	43.13±2.05^{ab}	43.16±0.65^a	42.05±0.72^b	0.000
MCH pg	29.56±5.62^a	23.03±2.04^b	25.96±2.48^c	0.000
MCHC g/dL	68.41±9.97^a	53.56±4.44^b	61.86±5.47^c	0.000
PLT ($\times10^9$/L)	164.30±59.24	143.76±45.27	163.92±46.53	0.282
MPV fL	6.746±1.01^a	5.77±0.64^b	6.19±0.71^b	0.000

a,b,c; Means within a column with different superscripts differ significantly ($p<0.05$). RBC; Number of red blood cells, HGB; Haemoglobin concentration, HCT; Haematocrit, MCV; Mean corpuscular volume, MCH; Mean corpuscular haemoglobin, MCHC; Mean corpuscular haemoglobin concentration, PLT; Number of Platelets, MPV; Mean Platelet Volume.

water intake and also to the fluid losses with the beginning of lactation and subsequent dilution of erythrocyte and hyper-hydration (Bonelli *et al,* 2016). Furthermore, low value of RBC, HCT and HGB perhaps was attributed to the physiological haemodilution during lactation that improves the flow of the blood into the udder in response to high demand of milk production.

The current study demonstrated that there were significant differences during lactation in MCV, followed by a decrease during late lactation. Similar results were reported in camel by Hussein *et al* (1992) and El-Sayed (2020). On the other hand, no significant difference was reported in MCV during lactation in camels (El-Zahar *et al,* 2017), Mehshani buffaloes (Das *et al,* 2016), Baladi goats (Azab and Hussein, 1999) and Jennies (Bonelli *et al,* 2016). The current study reported a significant difference in MCH and MCHC during lactation. Similarly, Hussein *et al* (1992) and El-Sayed (2020) reported a significant difference in MCH but not in MCHC during lactation in camel, however, no significant difference was reported in both MCH and MCHC in camel (El-Zahar *et al,* 2017), in Mehshani buffaloes (Das *et al,* 2016), Baladi goats (Azab and Hussein, 1999) and Jennies (Bonelli *et al,* 2016). The high value of MCHC, MCH and MCV during early lactation could be due to the increase of the capacity of the red blood cell for oxygen fixation and due to the physiological haemodilution that improves the flow of the blood to the udder as a response to the high demand of milk production. There was no significant difference in the PLT during the difference stages of lactation. Similar result was reported in Mehshani buffaloes (Das *et al,* 2016) and Jennies (Bonelli *et al,* 2016). A higher value of MPV was seen during the first stage of lactation followed by a significant decrease. This result was near to the value that detected earlier in non-pregnant female camel (Hussein *et al,* 2010). This study would help in standardisation of haematological parameters with maximum and minimum limits in order to serve as a guide for monitoring the camel population raised in local conditions.

Conflict of Interests

The authors have not declared any conflict of interests.

References

Azab ME and Hussein AA. Changes in some haematological and biochemical parameters during prepartum and postpartum periods in female Baladi goats. Small Ruminant Research. 1999; 34(1):77-85.

Bonelli F, Rota A, Corazza M, Serio D and Sgorbini M. Hematological and biochemical findings in pregnant, postfoaling and lactating jennies. Theriogenology. 2016; 85(7):1233-1238.

Braun U and Forster E. B-mode and colour Doppler sonographic examination of the milk vein and musculophrenic vein in dry cows and cows with a milk yield of 10 and 20 kg. Acta Veterinaria Scandinavica. 2012; 54(1):15.

Coroian CO, Mireşan V, Coroian A, Răducu C andronie L, Marchiş Z, Terheş S and Muntean MV. Biochemical and haematological blood parameters at different stages of lactation in cows. Bulletin UASVM Animal Science and Biotechnologies. 2017; 74(1):32-36 .

Das D, Lateef A, Panchasara HH and Ayub Ali M. Haemato-biochemical alterations during different stages of lactation in Mehshani buffaloes. Buffalo Bulletin. 2016; 35(3):307-315.

El-Zahar H, Zaher H, Alkablawy A and Al Sharifi S, Swelum A. Monitoring the changes in certain haematological and biochemical parameters in camels (*Camelus dromedarius*) during postpartum period. Journal of Fertility Biomarkers. 2017; 1(1):47-54.

El-Sayed A. Evaluation of hematological and biochemical changes in dromedary camel during the different stages of lactation. Mansoura Veterinary Medecine Journal. 2020; 21:121-124.

Hagawane SD, Shinde SB and Rajguru DN. Haematological and blood biochemical profile in lactating Buffaloes in and around Parbhani city. Veterinary World. 2009; 2(12):467-469.

Hussein M, Aljumaah R, Alhaidary A, Alshaikh M, Mohammed O, Omer S, Gar-Elnabi A and Macasero W. Platelet indices of the dromedary camel (*Camelus dromedarius*). Veterinary Archives. 2010; 80(3):375-382

Hussein MF, Salah MS, Mogawer HH and Gar ElNabi AR. Effect of lactation on the haemogram and certain blood constituents of the dromedary camel. Journal of Applied Animal Research. 1992; 1(1):43-50.

Hussein YA, Al-Eknah MM, AL-Shami SA, Mandour MA and Fouda TA. Coat colour breed variation in blood constituents among indigenous Saudi Arabia camel strains. Mansoura Veterinary Medical Journal. 2012; 14:191–204.

Iriadam M. Variation in certain haematological and biochemical parameters during the pre-partum period in Kilis does. Small Ruminant Research. 2007; 73(1-3):54-57.

Krajnicakova ME, Hendrichovscky V and Maracek I. Concentrations of total lipid, cholesterol and progesterone during oestrus synchronisation and pregnancy in sheep. Veterinary Med-US. 1993; 38(6):349-357.

Piccione G, Caola G, Giannetto C, Grasso F, Runzo SC, Zumbo A and Pennisi P. Selected biochemical serum parameters in ewes during pregnancy post parturition, lactation and dry period. Animal Science Papers and Reports. 2009; 27(4):321-330.

DOI : 10.5958/2277-8934.2024.00005.5 *Vol 31 No 1, p 29-32*

NOCARDIOSIS IN A DROMEDARY CAMEL-CASE REPORT

Fatma Al Mheiri, Marina Joseph, Jörg Kinne, Sunitha Joseph, Shantymol V Jose and Ulrich Wernery
Central Veterinary Research Laboratory, Dubai, UAE

ABSTRACT

This case report investigated the occurrence of Nocardial mastitis in a dromedary camel, emphasising key aspects of etiology and pathogenesis. The female camel presented with chronic udder abscesses, haematuria, pyrexia and recumbency, underwent necropsy at the Central Veterinary Research Laboratory. Gross pathological findings revealed extensive abscesses and lesions in multiple organs, including the heart, lungs, liver, spleen, brain and kidneys. The udder exhibited suppurative mastitis with nodules and purulent milk. Notably, severe hepatic amyloidosis was observed in 80% of the hepatic tissue. Combining macroscopic and microscopic analyses, provided a comprehensive understanding of Nocardial mastitis in this dromedary camel. Bacterial isolation from collected specimens further contributed to clarifying the microbial involvement in this case.

Key words: Dromedary camel, gross-pathology, mastitis, nocardia

Nocardiosis is a non-contagious opportunistic pyogranulomatous disease of domestic animals, wildlife and people (Rawat *et al,* 2023). Infections in livestock, companion animals and people are rare, but have increased in the recent years (Merck, 2016). Infections are acquired through inhalation, traumatic percutaneous introduction of the organism through wounds, abrasions of the skin, ingestion or by the intra mammary route. In cattle and small ruminants and also camels, it is considered an organism of environmental origin, for example soil, organic material, water, compost vegetation and other environmental sources (Ayadi *et al,* 2016). It is a pleomorphic, non-motile non-capsulated, strict aerobic, gram-positive actinomycete which forms characteristic long or branching filaments with a tendency of producing rods and cocci. Many different Nocardia species exist, but the most important pathogenic species for animals and people are represented by the Nocardia asteroides complex (Rahmeh *et al,* 2022). Some pathogenic species of Nocardia exhibit partial acid-fast characteristics and this organism is characterised by thin, delicate branching filaments in bacillary forms. Nocardia is commonly found in the environment, thriving on dead or decaying organic material and has been isolated from diverse sources including soil, water, air, dust and the skin of healthy cows' udders. Systemic nocardiosis occurs through haematogenous dissemination, resulting in abscess formation in various organs. The disease is characterised by a chronic, antimicrobial-resistant progression, leading to extensive granulomatous lesions in the mammary gland and eventual udder destruction. Herds with inadequate milking parlor management and poor hygiene conditions are particularly susceptible to Nocardial mastitis (Bättig *et al,* 1990; Aqib *et al,* 2022).

This case report describes systemic nocardiosis including mastitis in a dromedary camel, focusing on key aspects of etiology, pathogenesis and mastitis diagnosis.

Materials and Methods

A female dromedary camel in a fair to good body condition with no wound lesions was sent to the Central Veterinary Research Laboratory (CVRL), where a necropsy was performed. The female camel was presented with a history of chronic udder abscess in both rear quarters, haematuria, pyrexia and recumbency. The pre-necropsy inspection exhibited significant engorgement of the superficial epigastric vein additionally an inflammed, swollen and enlarged udder was observed which indicated suppurative mastitis. Both rear quarters revealed pendulous structures and blown-up teat shape (Ayadi, 2016) (Fig 1). To comprehensively analyse these pathological observations, the following specimens were collected during the necropsy for further analysis: lung tissue, liver tissue, intestinal tissue, kidney abscess, udder

SEND REPRINT REQUEST TO FATMA AL MHEIRI email: cvrl@cvrl.ae

tissue and mammary gland and additional specimens like swabs from kidney and lung. Additionally exudate like pericardial fluid, abdominal fluid, milk and cyst were obtained as well.

Results

Upon necropsy a thorough examination of all visceral organs is essential, including the mammary gland. The gross pathological findings were observed and bacteriological and histological samples were obtained. The thoracic cavity had congested parietal pleura with some fibrin formation in the pleural cavity of the heart. A small white myocardial abscess was also observed in the right ventricle (Fig 2). The lungs showed hypostatic congested and oedematous lungs with multiple abscesses and cysts. Emphysema of the apical lungs was detected on the edge of the caudal lung (Fig 3). The abdominal cavity exhibited necrotic fat on the abdominal wall and the liver was pale, waxy with chestnut appearance (Fig 4). The spleen displayed severe congestion and haemorrhages. Many small abscesses were present in the renal cortex, accompanied by multifocal lesions (Fig 5). Haematoma was seen in the uterine body with scattered dark brown lesions across the endometrium.

Upon dissecting of udder, huge amount of white pus was noticed deep in the gland cistern and the major milk ducts reaching up to the glandular complex with a lot of cutaneous material (Fig 6). Multiple nodules were dispersed throughout the udder parenchyma and purulent milk, appearing white to yellow with visible granules, in the mammary gland. Additionally, our investigation unveiled an abscess with pus, approximately 2 cm in diameter, located in the temporal lobe and midbrain of the cerebrum (Fig 7).

Histopathological changes were severe hepatic amyloidosis with 80% of the tissue occupied by amyloid-deposits (Fig 8). Linking the previous observations of our investigations, the subsequent step involved the bacterial isolation of the microorganisms

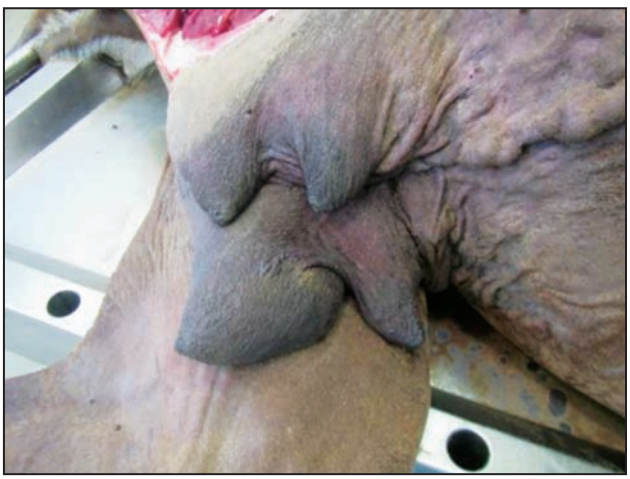


Fig 1. Pendulous udder quarters and blown-up teats shape.

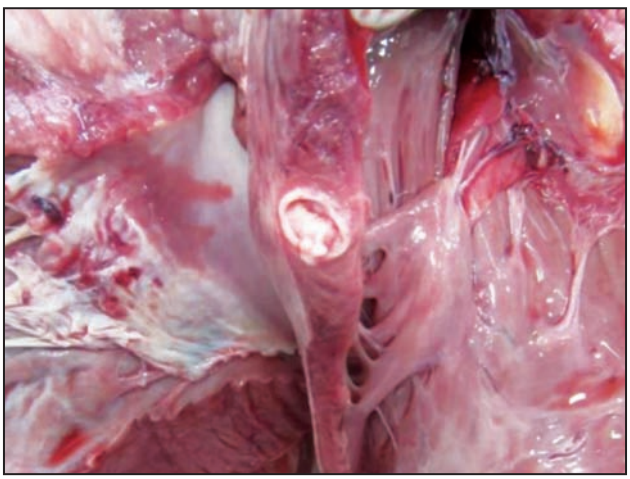


Fig 2. Myocardial abscess with white pus formation.

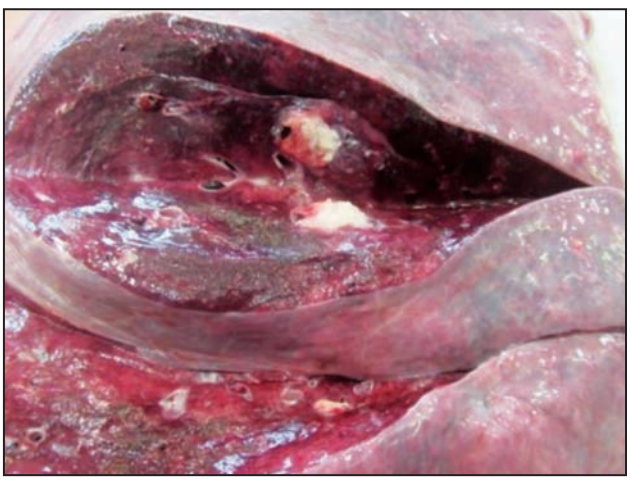


Fig 3. Caseous abscesses in the lung.

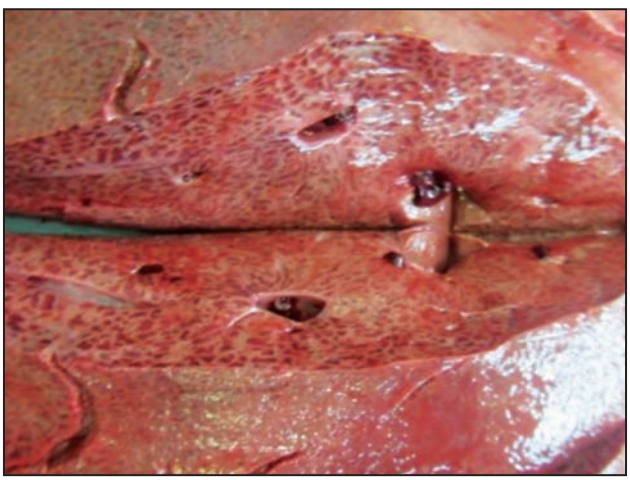


Fig 4. Waxy chestnut liver.

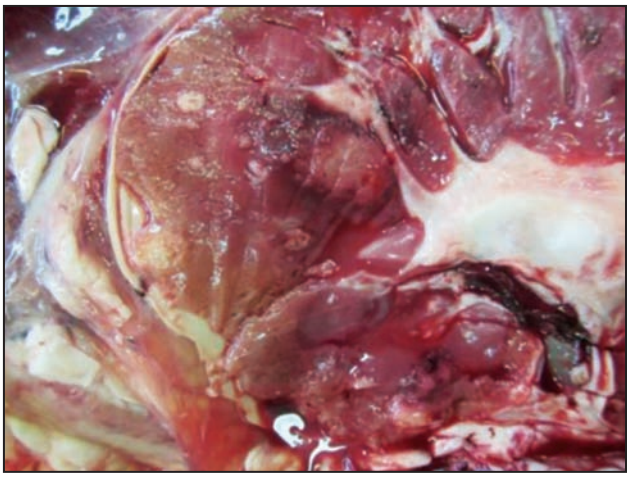


Fig 5. Renal abscess formation.

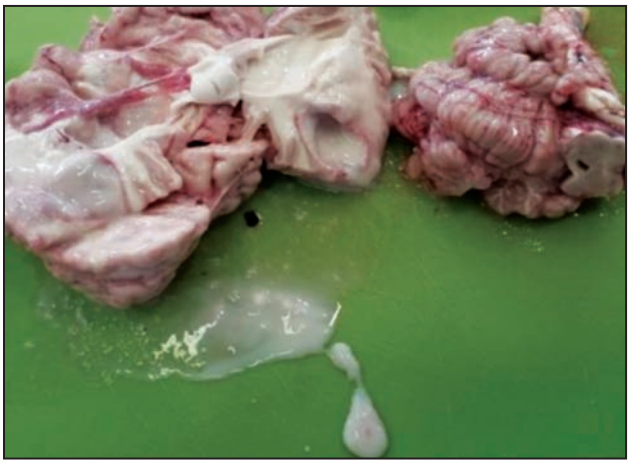


Fig 7. Brain abscess.

from the collected specimens, as outlined in Table 1. This integrative approach, spanning macroscopic and microscopic analyses, allows for a more comprehensive understanding of the pathology and microbial involvement in the identified case of Nocardia isolation in dromedary camels.

Discussion

We report here a generalised Nocardia infection in a lactating dromedary camel resulting in multiple abscesses, including those in brain and udder. Nocardia is an agent of mastitis of environment origin and is predominantly caused by soil contamination of the teats. From the udder, the pathogen most probably spread through haematogenous dissemination to all other organs producing multiple abscesses. Nocardial mastitis is generally described as a chronic infection and is usually refractory to antimicrobial therapy. The disease can be avoided with antibiotic. However, in this case no information was received if the camel was treated and if so with which antibiotics. Blood sheep agar and sabouraud

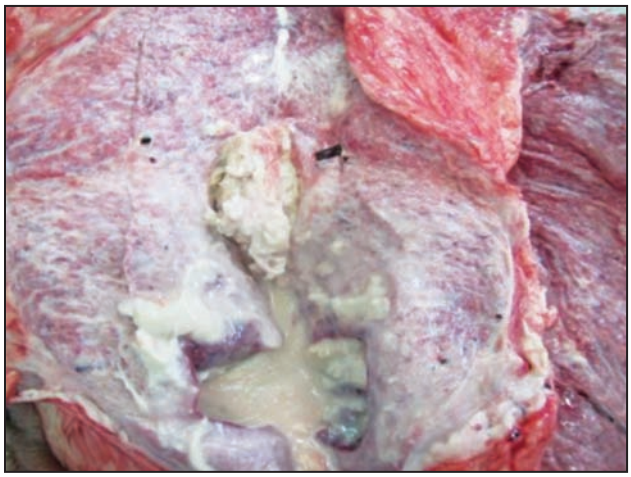


Fig 6. Pyogranulomatous mastitis with white cutaneous material and pus in the gland cistern and the ducts.

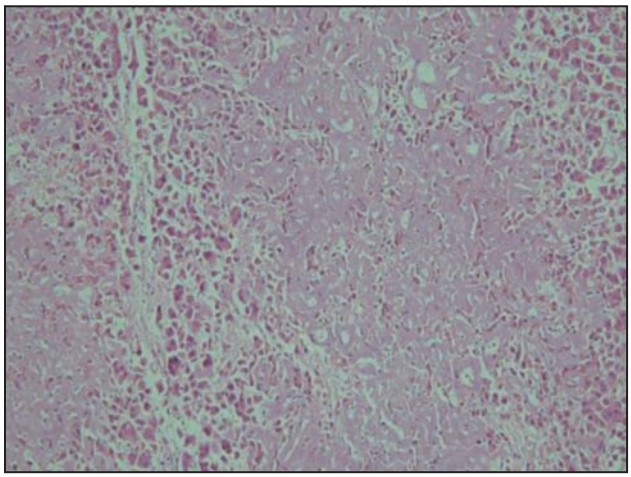


Fig 8. Severe hepatic amyloidosis with 80% of the tissue occupied by amyloid-deposits (HE, 10X objective).

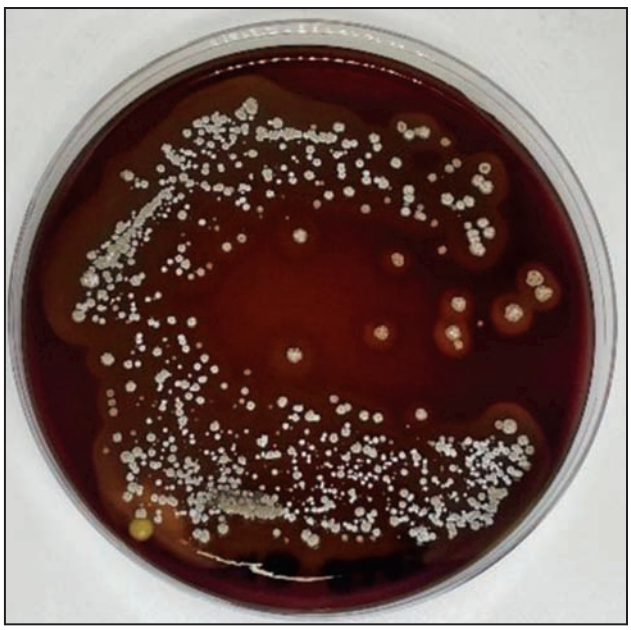


Fig 9. Nocardia colonies growing on the blood agar.

Table 1. Summary of the microorganisms that were isolated from the collected specimens.

Samples collected	*E. coli*	*Cl. perfringens*	*Nocardia* sp	*Corynebacterium jeikeium*	*Enterococcus faecalis*
Lung	+	N/A	N/A	N/A	N/A
Liver	+	N/A	N/A	N/A	N/A
Intestine	N/A	++++	N/A	N/A	N/A
kidney abscess	+++	N/A	+++	N/A	N/A
Udder	++++	N/A	+++	+++	N/A
Mammary gland	+	N/A	+++	N/A	++++
Swab (lung)	++++	N/A	++++	N/A	N/A
Swab (kidney)	+++	N/A	+++	N/A	N/A
Pericardial fluid	++++	N/A	N/A	N/A	N/A
Abdominal fluid	++++	N/A	N/A	N/A	N/A
Milk	+	N/A	+++	++	+++
Cyst	++++	N/A	N/A	N/A	N/A

plates were incubated with the specimen of all organs and incubated aerobically at 37°C for up to 7 days. The colonies growing on the blood sheep agar after 3 days were white and powdery in appearance and firmly adherent to the medium (Fig 9). Gram-stained smears from colonies showed gram-positive branching filaments that broke up into rods with age. In comparison to Streptomyces and Actinomyces, the Nocardia asteroides bacteria stained red with modified Ziehl-Neelsen.

Infusion technique, proper sanitation of hands, teats, wearing gloves and the use of single use treatment devices is a highly effective prevention. Nocardiosis in camels has not been clearly described or rare and this is the first report.

References

Aqib AI, Muzammil I, Naseer MA, Shoaib M, Bakht P, Zaheer T, Khan YR, Khan RL, Usman M, Shafeeq M, Tanveer Q, Hussain HI, Saleem A and Prince K. Pathological insights into camel mastitis. Acta Tropica, 2022; 231:106415. https://doi.org/10.1016/j.actatropica.2022.106415

Ayadi M, Aljumaah RS, Samara EM, Faye B and Caja G. A proposal of linear assessment scheme for the udder of dairy camels (*Camelus dromedarius* L.). Tropical Animal Health and Production. 2016; 48(5):927-933. https://doi.org/10.1007/s11250-016-1051-4

Bättig U, Wegmann P, Meyer B and Penseyres JH. Die Nokardien-Mastitis des Rindes 1. Klinische Beobachtungen und Diagnose an 7 Einzelfällen [Nocardia mastitis in cattle. 1. Clinical observations and diagnosis in 7 particular cases]. Schweizer Archiv für Tierheilkunde. 1990; 132(6):315-322.

Merck RE. Nocardiosis. In J. H. Penseyres (Ed.), Nocardia mastitis in cattle: Clinical observations and diagnosis in 7 particular cases (pp. 315-322). Schweizer Archiv für Tierheilkunde. 2016.

Rahmeh R, Akbar A, Alomirah H, Kishk M, Al-Ateeqi A, Shajan A, Alonaizi T and Esposito A. Assessment of mastitis in camel using high-throughput sequencing. PLoS One. 2022; 17(12):e0278456. https://doi.org/10.1371/journal.pone.0278456

Rawat D, Rajasurya V, Chakraborty RK *et al*. Nocardiosis. In StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing. 2023. Available from: https://www.ncbi.nlm.nih.gov/books/NBK526075/

DOI : 10.5958/2277-8934.2024.00006.7 Vol 31 No 1, p 33-34

Short communication

PARALYSIS OF A DROMEDARY CAMEL CAUSED BY *Hyalomma dromedarii* INFESTATION

U. Wernery, C. Hebel, F.G. Al Mheiri, R.K. Schuster and J. Kinne
Central Veterinary Research Laboratory, Dubai, UAE

ABSTRACT

A heavy tick infestation is reported, causing paralysis in an old female dromedary camel with all stages of *Hyalomma dromedarii*. The diagnosis relied solely on clinical signs due to a lack of specific methods for identifying tick neurotoxin(s). No gross or microscopic lesions were observed except for mild to marked demyelination of the spinal cord white matter.

Key words: *Hyalomma dromedarii*, hind leg paralysis

Tick paralysis is an acute, progressive, symmetrical, ascending motor paralysis caused by salivary toxins from specific tick species. A wide range of mammals, birds, reptiles, and even humans can be affected. In humans, tick paralysis is primarily caused by ticks of the genus Ixodes, *Dermacentor*, and *Amblyomma,* and has been reported in Australia, South Africa, North America, and Europe (Merck, 2016). Young domestic animals heavily infested with ticks often experience paralysis (Radostits *et al,* 2007).

It is important to distinguish tick paralysis or toxicity from tick-borne diseases or tick-borne fever like those caused by Rickettsiae, transmitted through tick bites. Wernery (2022) recently reviewed rickettsial infections in dromedaries, highlighting limited knowledge on Rickettsiosis in camels with reported infections but no confirmed disease. Even less is known about tick paralysis in camels.

We report here a possible case of tick paralysis in an adult female dromedary camel caused by *Hy. dromedarii*.

Materials and Methods

A female adult dromedary camel weighing approximately 300 kg was found in a sitting position at a small camel farm in the Dubai Emirate. The animal was unable to stand despite attempts to lift it with a crane. A neurological examination revealed a complete loss of deep sensation in the hind legs. Due to ethical concerns regarding the animal's suffering and limited chances of recovery, a decision was made to euthanase the camel. The euthanase protocol followed established guidelines. Following euthanasia, the camel was transported to the Central Veterinary Research Laboratory (CVRL) in Dubai for further investigation.

Results

Necropsy findings

Examination of the camel post-mortem revealed multiple *Hy. dromedarii* ticks attached throughout the body, including larvae, nymphs, and engorged females (Fig 1). The urinary bladder was distended with urine, and the rectum contained a large amount of faecal material. No other significant macroscopic lesions were observed in internal organs, including the brain and spinal cord.

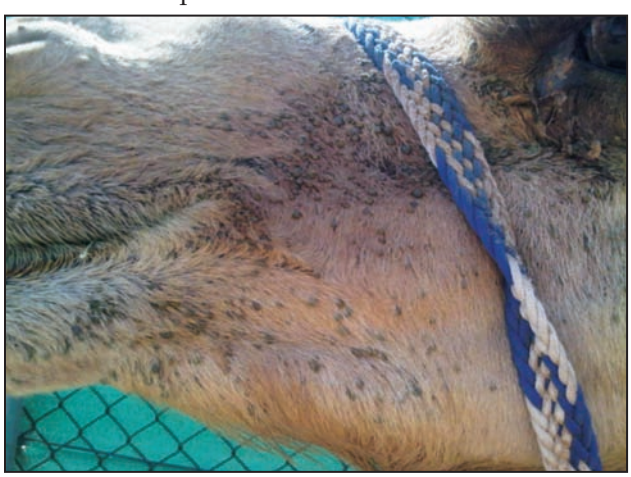


Fig 1. Female dromedary camel head infested with *Hyalomma dromedarii*.

SEND REPRINT REQUEST TO U. WERNERY email: cvrl@cvrl.ae

Blood and histopathology

Blood parameters from blood obtained before euthanasia, were within normal ranges except for an elevated creatine kinase (CK) level.

Blood trace elements of selenium and zinc did not show any abnormality, while the serum copper level was found to be 10.83 µmol/l (ref.-value between 9.00-14.00 µmol/l, Wernery *et al,* 2009). The copper level of the liver was below the reference value (18.00 – 140.00 ppm per weight per gram) with 13.40 ppm wet weight copper per gram liver.

Histological examination revealed no abnormalities in the brain but showed mild to moderate demyelination in the spinal cord white matter.

Discussion

We report a possible case of tick paralysis in an adult female dromedary camel caused by *Hy. dromedarii* ticks.The animal exhibited a rapid progression of hind leg paralysis, culminating in complete recumbency within 48 hours of onset. The attempt to lift the animal up by crane did not succeed, necessitating the decision to euthanase the camel for animal welfare reasons. The severe, progressive nature of the paralysis, coupled with the presence of numerous *Hy. dromedarii* ticks in various life stages on the camel's body points to a possible tick paralysis. Specific diagnostic tools for identifying the salivary neurotoxin responsible for tick paralysis are currently not available. Therefore, epidemiological and clinical context is needed to support the theory. As haematology and biochemistry values were largely within the normal range, except for the elevated CK. The increased CK can have various causes like muscle damage from trauma, hypoxia, thrombosis, recumbency, vitamin E and selenium deficiency, inflammatory myositis and neoplasia. The toxins may also have an effect on the CK levels in the blood. Mineral values like calcium, sodium, magnesium and potassium were in the reference value range. Blood trace elements of selenium, zinc and copper did not show any abnormality. However, the copper levels in the liver were below the reference value (18.00 – 140.00 ppm wet weight per gram) with 13.40 ppm wet weight copper per gram liver. This decreased copper value might have contributed to the severe paralysis. Camels have shown to exhibit a higher tolerance for mineral deficiencies compared to other ruminants (Bengoumi *et al,* 2002).

Previous reports have documented cases of tick paralysis in camels. Manefield and Tinson (1996) described mild paresis in Australian camel calves infested with *Ixodes holocyclus* ticks. Barre and Uilenberg (2010), suspected *Hy. dromedarii* in paralysis cases in North-East Africa. Additionally, Musa and Osman (1990) reported an outbreak in Southern Darfur, Sudan involving 251 camels with clinical signs of incoordination, unsteady gait, paralysis and recumbancy attributed to infestation with *Hy. dromedarii* and *Rhipicephalus* ticks.

Even though our investigation did not yield new insights into the gross and histopathological changes associated with tick paralysis in camels, there is a potential for underdiagnosis of this condition, warranting further research in this area. Notably, the successful utilisation of tick antitoxin serum (TAS) and antibiotic treatment in canine tick paralysis cases (Atwell and Campbell, 2001) suggested promising possibilities for future exploration in camels.

References

Atwell RB and Campbell FE. Reactions to tick antitoxin serum and the role of atropine in treatment of dogs and cats with tick paralysis caused by *Ixode sholocyclus:* a pilot survey. Australian Veterinary Journal. 2001; 70(6):394-7.

Barre N and Uilenberg G. Ticks pathogenicity and control. In: Infectious and Parasitic Diseases of Livestock. Eds. Lefèvre P-Ch., J Blancou, R Chermette and G Uilenberg. Lavoisier, Paris. 2010; pp 125-136.

Bengoumi M, Essamadi A and Faye B. Mineral nutrition in the camel. Camel newsletter of the Arab centre for Studies of Arid Zones and Dry lands. 2002; pp 31-58.

Manefield GW and Tinson AH. Camels: A Compendium Series C, No 22. University of Sydney. Post-Graduate Foundation in Veterinary Science, 1996; pp 262.

Merck. The Merck Veterinary Manual. 11th ed. Tick Paralysis. 2016; pp 1314-1320.

Musa MT and Osman OM. Suspicion d'un foyer de paralysie due aux tiques chez le dromadaire (*Camelus dromedarius*) au Soudan. Revue d'Elevage et de Medecine Veterinaire des Pays Tropicaux. 1990; 43(4):505-510.

Radostits OM, Gay CC, Hinchcliff KW and Constable PD. Veterinary Medicine, chapter. 2007; 26, pp 1599.

Wernery U. Rickettsiales and Coxiella burnetii infections in camelids: A Review. Journal of Camel Practice and Research. 2022; 29(1):1-6.

Wernery U, Abraham A A, Jyothi T, AbubakarAli Y and George RM. Mineral and vitamin contents in the blood of racing dromedaries in the United Arab Emirates. Journal of Camel Practice and Research. 2009; 16(1): 39-40.

DOI : 10.5958/2277-8934.2024.00007.9 *Vol 31 No 1, p 35-42*

LOCALISATION OF AQUAPORIN1 IN THE VAS DEFERENS AND PROSTATE GLAND OF THE DROMEDARY CAMEL (*Camelus dromedarius*) DURING RUTTING AND NON-RUTTING SEASON

Abdelrahman M. A. Elseory[1,2]

[1]Department of Anatomy, College of Veterinary Medicine, King Faisal University, Saudi Arabia, P.O. Box 400, Al-Ahsa 31982, Saudi Arabia

[2]Department of Anatomy, Faculty of Veterinary Medicine, University of Khartoum, PO Box: 32, Postal code: 13314 Shambat, Khartoum North, Sudan

ABSTRACT

A membrane protein channel, Aquaporin 1 (AQP1), enables the fast water flow through the epithelium. Using the immunohistochemistry technique, the current work elucidated the presence of AQP1 in the vas deferens and prostate gland of dromedary camels in rutting and non-rutting seasons throughout the year. The immunohistochemistry of AQP1 revealed a strong immunoreactive in the epithelial cells of the initial vas deferens at the beginning of the rutting season (October and November). During December and January, this expression became moderate, and by its end (February and March), it seemed pale. The middle vas deferens epithelium and luminal sperms displayed high levels of AQP1 protein in the first and second third of the season. There has been little immunoreaction to the protein in recent months. At the start of the rutting season, the ampullary vas deferens moderately reacted to AQP1 antibodies; however, from December through March, this response decreased to a weak state.

In the non-rutting season, the middle part of the vas deferens exhibited a significant immunoreaction to AQP1. The initial vas deferens showed a strong immunoreaction in April and May before decreasing to appear mildly for the remainder of the season. AQP1 showed a weak expression in the ampulla at this time. AQP1 was not clearly expressed by the prostate gland over the year. In conclusion, it is possible that AQP1 has a role in spermatozoa migration via the male genitalia of camels and may even facilitate the flow of water, which is necessary for sperm motility.

Key words: Aquaporin 1, camel, immunohistochemistry, prostate gland, vas deferens

Aquaporins (AQPs) are membrane proteins that assist in moving water and other tiny solutes across biological membranes. They are a family of tiny, hydrophobic integral membrane channel proteins that speed up the passive transport of water. Mammals have been found to have 13 isoforms of AQPs (AQP0-AQP12), to date (Carrageta *et al,* 2020). Different AQPs have been found in several tissues of mammals including the male genital system (Stevens *et al,* 2000). In 1992, AQP1 was discovered in human erythrocytes (Preston *et al,* 1992). AQP1 was found to be expressed in the organs of the male reproductive tract of many mammals including the dromedary camel, human, horse, buffalo-bull, dog, cat, and fruit-eating bat (Ito *et al,* 2008; Lu *et al,* 2008; Domeniconi *et al,* 2008; Skowronski *et al,* 2009; Yeung *et al,* 2010; Oliveira *et al,* 2013; Klein *et al,* 2013; Arrighi and Aralla, 2014; Arrigh *et al,* 2016; An and Wang, 2016; Althnaian, 2023), where, water absorption and sperm concentration control in the male genital organs are major AQP1 functions (Brown *et al,* 1993; Nicotina *et al,* 2004; Nicotina *et al,* 2005; Lu *et al,* 2008; Arrighi *et al,* 2010b). According to the authors' knowledge, there is previous study about the expression of AQP1 in the dromedary's testis and epididymis. Thus, using the immunohistochemical technique, the current investigation was carried out to find AQP1 in the vas deferens and prostate gland of the dromedary camel throughout rutting and non-rutting seasons all year long to complete the view of this protein in the male genital system.

Materials and Methods

The samples protocol was accepted by the ethics committee of King Faisal University (Ref. No. KFU-REC-2023-MAY-ETHICS887). Samples were obtained from 36 healthy adult local breed dromedary camels (age 4-10 years) from local

SEND REPRINT REQUEST TO ABDELRAHMAN M. A. ELSEORY email: amamohamed@kfu.edu.sa

slaughterhouse in Al-Ahsa, Kingdoms of Saudi Arabia, on a regular monthly basis over the course of a year. These samples were taken from three parts of the vas deferens (initial, middle and ampulla) and prostate gland (corpus and disseminate parts) for immunohistochemically (IHC) analysis. Tissue samples were fixed in 10% buffered formalin for 36 hours, then were thoroughly washed in phosphate-buffered saline (PBS), embedded in paraffin wax after being dehydrated in graded ethanol. A rotary microtome was used to cut 5 micrometre-thick slices from each tissue. After that, tissue sections were deparaffinised by xylene, washed in ethanol alcohol and rehydrated in PBS. For fifteen minutes, antigen retrieval was carried out in a microwave oven using 0.01M PBS (pH 7.4). Thereafter, the sections were cooled at 25°C and washed again in PBS. 3% hydrogen peroxide was used for 30 minutes to block endogenous peroxidase. To prevent any non-specific reactions, the goat serum (10%) was utilised for 20 minutes after three rounds of washing in PBS. Then, the primary antibody, polyclonal rabbit anti-AQP1 was applied (Abcam, dilution 1:200) and incubated overnight in a wet chamber. Sections were incubated with biotin-labelled secondary antibodies and avidin-HRP third antibodies, DAB was used to detect the positive staining. Hematoxylin stain was used for section counter-staining. Negative control sections have the same procedure except for skipping the primary antibody. Slides were examined under light microscopy for histological studies, and photo-micrographs were taken.

Results

Expression of AQP1 immunoreactive protein was carried out using immunohistochemistry in the vas deferens and prostate gland of the dromedary camel during rutting and non-rutting season over a period of 12 months. Localisation and intensity of AQP1 in these organs were recognised and recorded in Tables 1 and 2, for the rutting and non-rutting seasons, respectively. Both seasons were clarified in Fig 1.

Table 1. Displaying AQP1 localisation throughout the **rutting season** in the different parts of the vas deferens and prostate gland of the dromedary camel.

Month Part	October- November	December- January	February- March
VI	+++	++	+
VM	+++	+++	+
VA	++	+	+
PD	+	+	+
PC	+	+	+

VI, initial vas deferens; VM, middle vas deferens; VA, ampullary vas deferens; PD, disseminated prostate; PC, corpus prostate; -, negative reaction; +, weak reaction; ++, moderate reaction; +++, strong reaction.

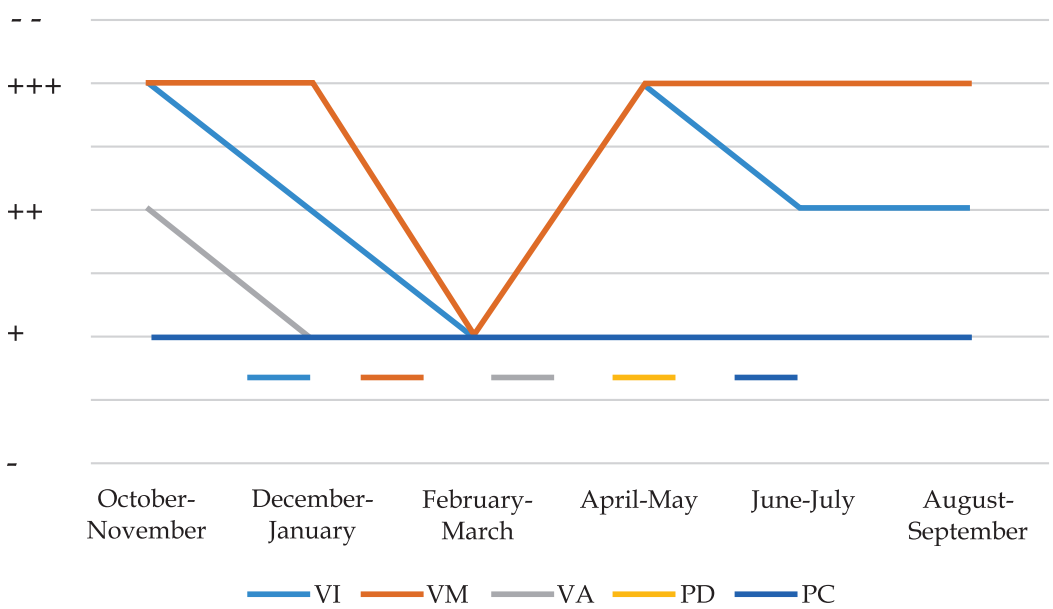


Fig 1. localisation of AQP1 in the vas deferens and prostate gland of the dromedary camel through the rutting and non-rutting seasons.

VI, initial vas deferens; VM, middle vas deferens; VA, ampullary vas deferens; PD, disseminated prostate; PC, corpus prostate

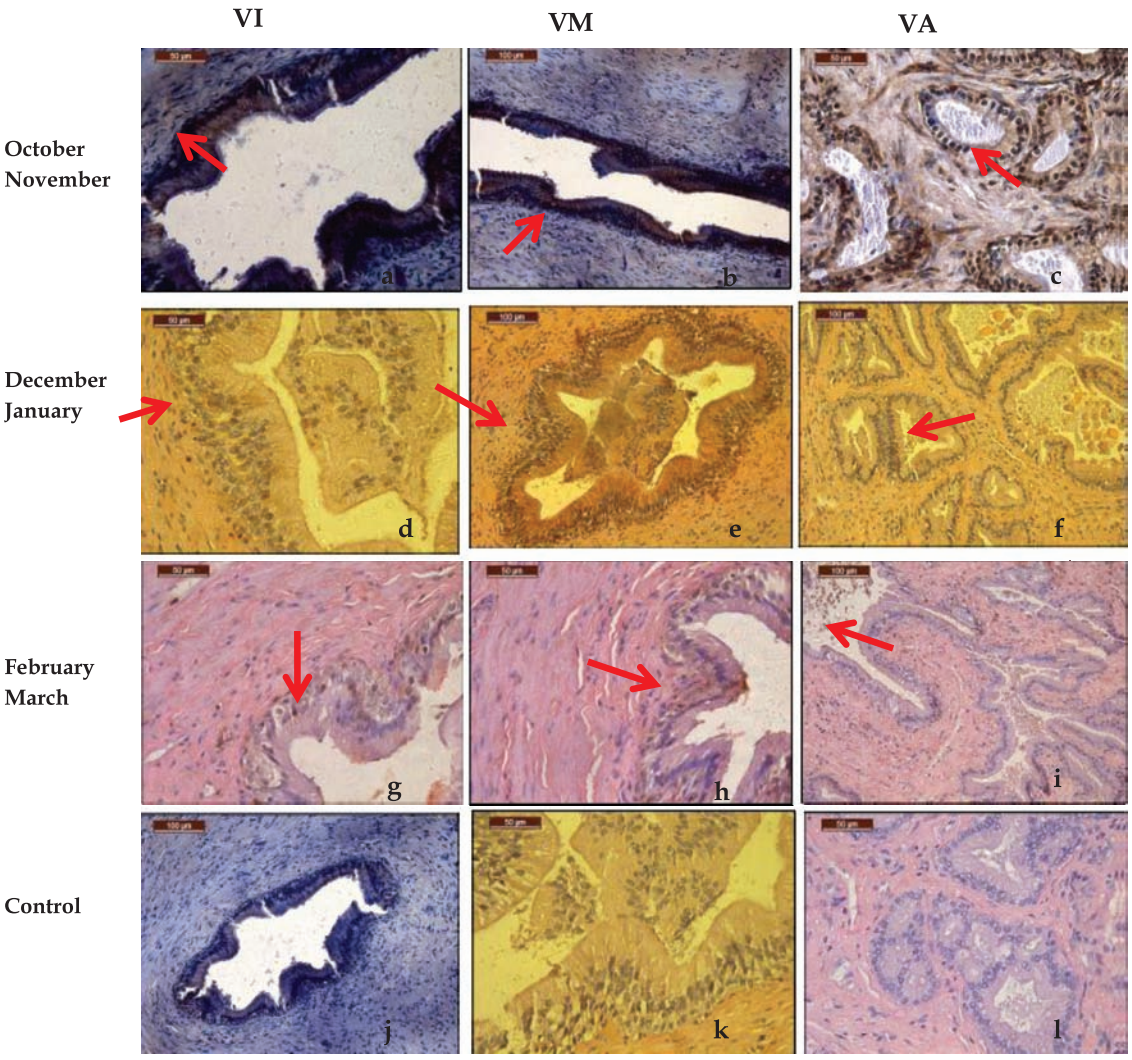


Fig 2. Micrograph of the dromedary camel's vas deferens at the beginning of the rutting season (October) showing a strong immunoreactive of AQP1 in the lining epithelium (arrow) of the initial (a) and middle (b) parts of the vas deferens, while, the ampullary vas deferens (c) showed a moderate reaction to the AQP1 antibodies. In December and January, the VI (d) lining epithelium (arrow) showed a moderate immunoreactive, which increased in the epithelium of VM (e) (arrow), while in VA (f), the epithelial cells had a weak immunoreaction to the AQP1 antibodies. At the end of the rutting season (February and March), a weak immunoreaction of AQP1 was recognized in the lining epithelium of all parts of the vas deferens VI (g), VM (h) and VA (i). (j, k, l) Negative control for initial, middle and ampullary parts of the vas deferens, respectively.

Table 2. Displaying AQP1 localisation throughout the **non-rutting season** in the different parts of the vas deferens and prostate gland of the dromedary camel.

Month Part	April- May	June- July	August- September
VI	+++	++	++
VM	+++	+++	+++
VA	+	+	+
PD	+	+	+
PC	+	+	+

VI, initial vas deferens; VM, middle vas deferens; VA, ampullary vas deferens; PD, disseminated prostate; PC, corpus prostate; -, negative reaction; +, weak reaction; ++, moderate reaction; +++, strong reaction.

Rutting season

The different parts of the vas deferens of the dromedary camel at the beginning of the rutting season (October and November) showed variety in reaction to AQP1 antibodies (Fig 2). A strong immunoreactive was recognised in the lining epithelium of the initial and middle parts of the vas deferens (Figs 2a, b), while, the ampullary vas deferens had a moderate reaction to the AQP1 antibodies (Fig 2c). In the second two months of the season, December and January, the lining epithelium of the initial part revealed a moderate immunoreactive (Fig 2d), which increased in the middle part of the organ (Fig 2e). While, the epithelial

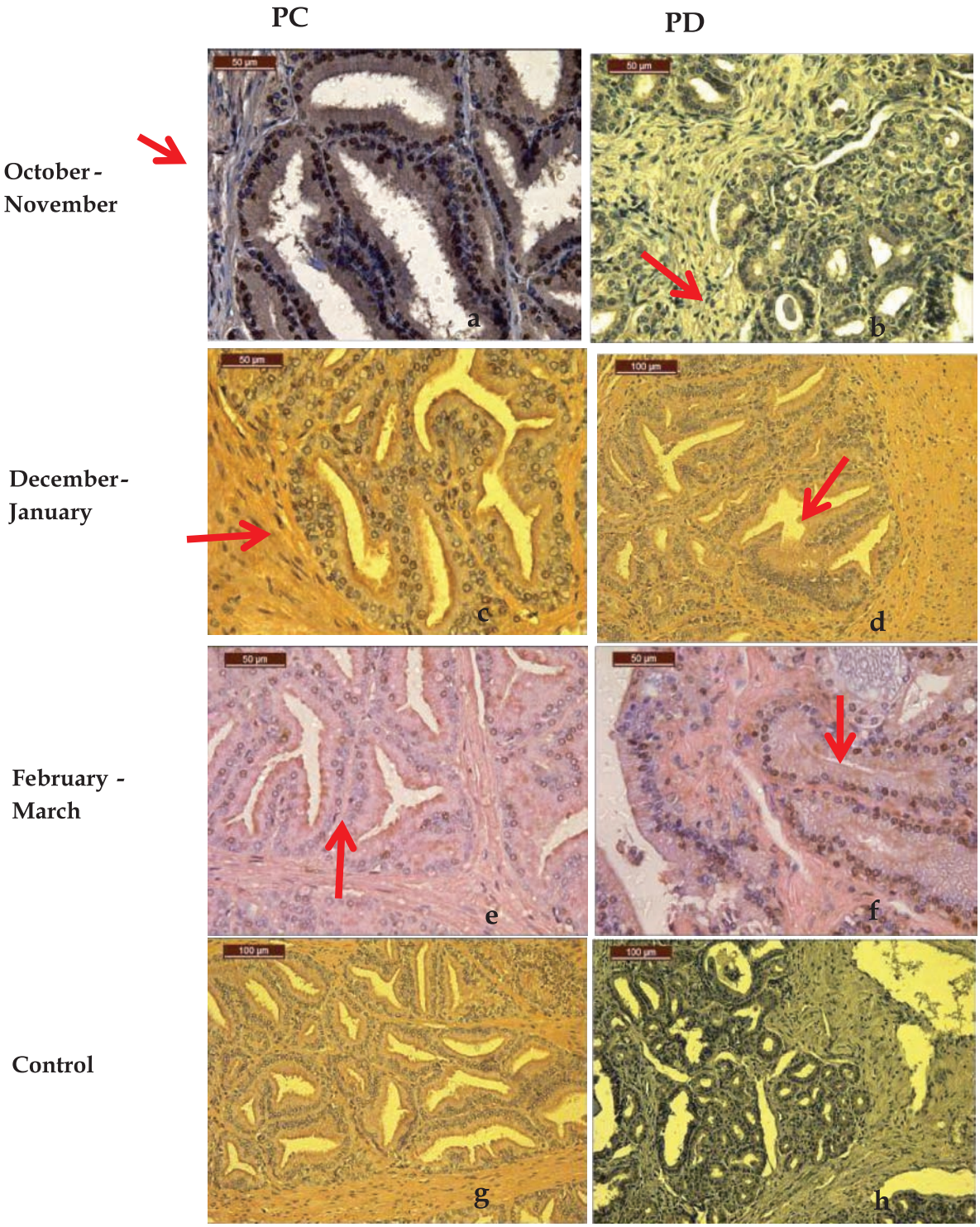


Fig 3. A micrograph showing a weak AQP1 immunoreactive in the lining epithelium (arrow) of the prostate gland in the dromedary camel during the rutting season. This immunoreactivity is recognized in both; the corpus prostate (PC) (a, c, e) and disseminated prostate (PD) (b, d, f) in October (a, b), December (c, d), and February (e, f), respectively. Negative control for the corpus prostate (g) and disseminated prostate (h).

cells of the ampullary vas deferens showed a weak immunoreactive to the protein (Fig 2f). At the last two months of the rutting season (February and March), the lining epithelium in all parts of the vas deferens demonstrated a weak immunoreaction to AQP1 antibodies (Fig 2g, h, i).

The prostate gland, both corpus and disseminate parts, in the dromedary camel during the

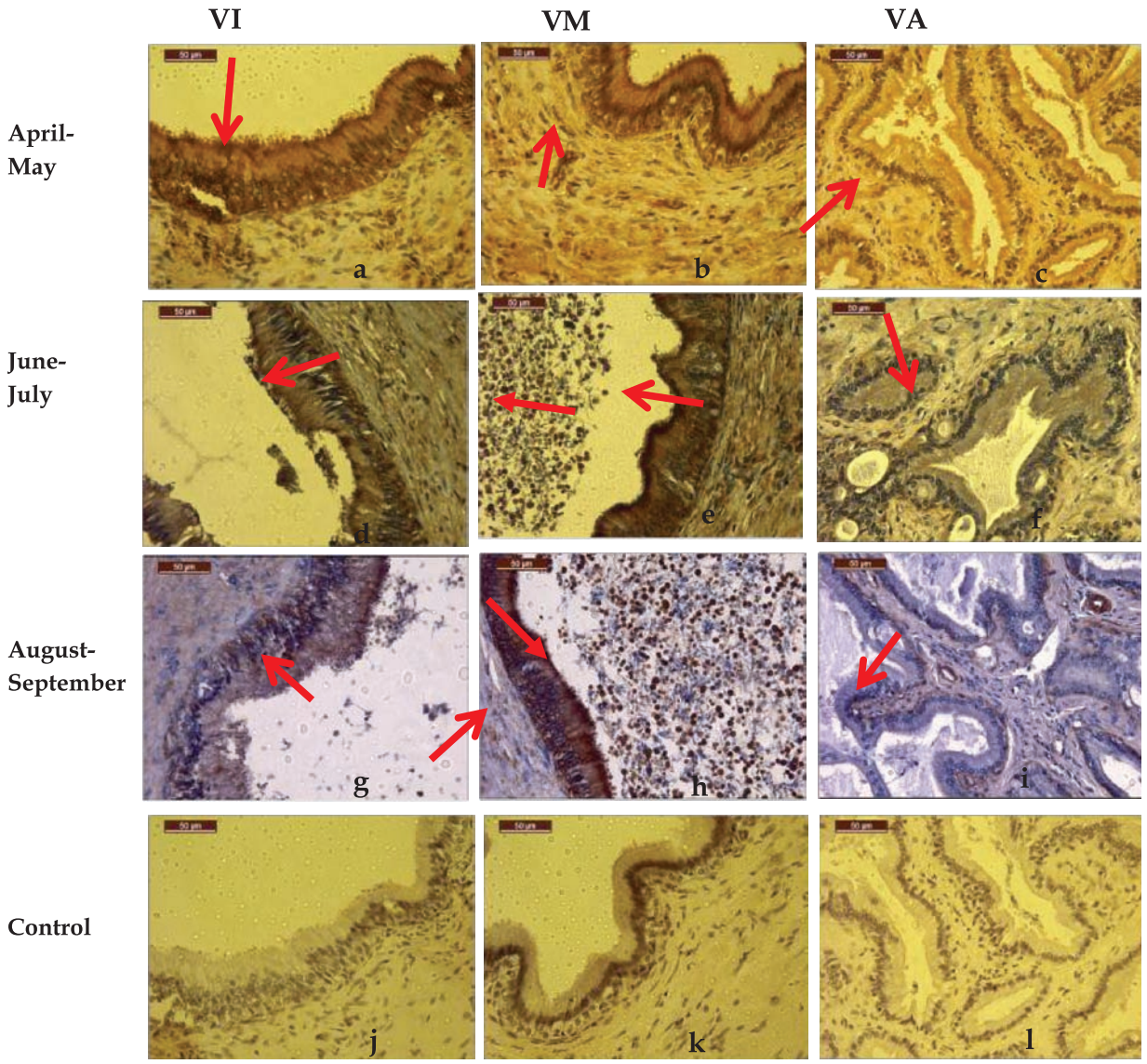


Fig 4. Micrograph of the dromedary camel's vas deferens at the beginning of the non-rutting season (April) showing a strong immunoreactive of AQP1 in the lining epithelium (arrow) of the initial (VI)(1) and middle (VM) (2) parts of the vas deferens, while, the ampullary vas deferens (VA) (3) showed a moderate reaction to the AQP1 antibodies. In the rest of the season, from June to September, the VI (4, 7) lining epithelium (arrow) showed moderate immunoreactive, whereas the epithelial cells of VM (5, 8) (arrow) verified a strong immunoreactive to AQP1 antibodies. The ampullary part (VA) (3, 6, 9) of the vas deferens showed weak immunostaining for AQP1 antibodies during the whole season. Negative control for initial (j), middle (k) and ampullary (l) vas deferens.

rutting season showed a weak AQP1 immunoreactive in their lining epithelium throughout the period (Fig 3a- f).

Non-rutting season

In the first third of this season, April and May, the initial and middle parts of the vas deferens of the dromedary camel showed a strong immunoreactive of AQP1 in their lining epithelium (Fig 4a, b). Whereas, the ampullary vas deferens revealed a moderate reaction to this protein (Fig 4c). In the rest of the season (from June until September), a moderate reaction was recognised in the lining epithelium of the first part of the vas deferens (Fig 4d, g), while, the middle part of this organ showed a strong immunoreaction to AQP1 antibodies (Fig 4e, h). The reaction appeared faint in the ampulla of the vas deferens during the whole season (Fig 4c, f, i).

Throughout the whole months of the non-rutting season, the two parts of the prostate gland, corpus prostate (Figs 5a, c, e) and diffused prostate (Fig 5b, d, f) of the dromedary camel demonstrated limited immunoreactivity for AQP1 antibodies.

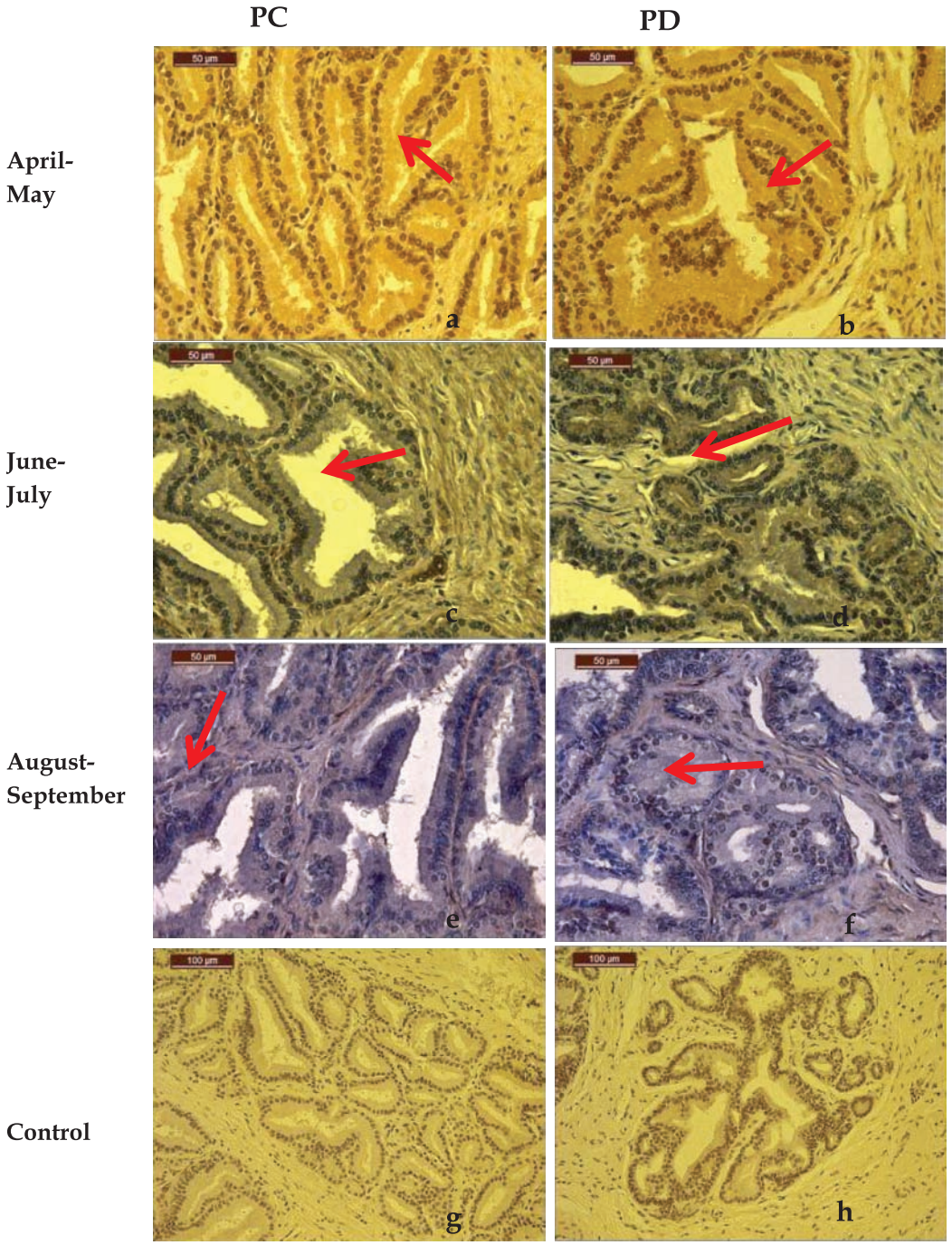


Fig 5. A micrograph showing a weak AQP1 immunoreactive in the lining epithelium (arrow) of the prostate gland in the dromedary camel during the non-rutting season. The immunoreactivity stain is seen in both; the corpus prostate (PC) (1, 3, 5) and disseminated prostate (PD) (2, 4, 6) throughout the whole season. (g, h) Negative control for the corpus and disseminated prostate, respectively.

Discussion

In the current study, the different parts of the dromedary camel's vas deferens exhibited a range of reactions to AQP1 antibodies throughout the year. In the months that started the rutting season (October and November), The lining epithelial cells of the initial vas deferens showed a strong immunoreactive stain to AQP1. This expression became moderate in the middle months of the season and at the end of this period appeared weak. In the same sequence of months, AQP1 protein expressed strongly in the epithelium and luminal sperms of the middle vas deferens in the first and second third of the season. While the last months showed a weak

immunoreaction to the protein. The ampullary vas deferens responded moderately to AQP1 antibodies at the beginning of the rutting season which reduced to become weak from December until March.

In the non-rutting season, generally, the middle part of the vas deferens showed strong immunoreaction to AQP1, while, the initial part revealed a strong reaction to it in April and May and decreased to appear moderately at the rest of the season. AQP1 expressed weakly in the ampulla during this period.

The presence of AQP1 in the vas deferens in this study is confirmed with the previous studies in the vas deferens of the Bactrian camel (An and Wang, 2016), mice (Zhou *et al,* 2001; Lu *et al,* 2008), cats (Arrighi *et al,* 2010b; Arrighi and Aralla, 2014) and buffalo (Arrighi *et al,* 2016). Furthermore, the location of AQP1 in the vas deferens is also widely agreed upon (Badran and Hermo, 2002; Da Silva *et al,* 2006).

On the other hand, the variety in the distribution of this protein in the parts of the vas deferens is in contrast with its function, where, the fluid reabsorption is regulated by steroids and may be facilitated by a variety of AQPs (Huang *et al,* 2006). Moreover, Da Silva *et al* (2006) and others reported that the vas deferens can modify its luminal environment other than simply transit spermatozoa.

The current investigation revealed that the dromedary camel's prostate gland expressed AQP1 faintly all year long. This expression resembles to the prostate gland of Bactrian camel and mice (Zhou *et al,* 2001; Lu *et al,* 2008; An and Wang, 2016). The localisation of AQP1 may play a critical role in water secretion into the seminal and prostatic fluid as well as the removal of water from the inter-tubular region. Since AQP1 is constitutively generated in epithelial cells and is less responsive to androgen or oestrogen regulation (Oliveira *et al,* 2005), the distribution of AQP1 in the prostate gland and ampulla of dromedary camels in this study remained constant in both seasons.

In conclusion, the current data support AQP1's primary function as a selective water channel, suggesting that AQP1 may be important for spermatozoa migration via the camel's male genital system and may even permit the outflow of water needed for sperm motility. As a result, AQP1 may someday function as a unique biomarker of male fertility and infertility.

Conflicts of Interest

The authors declare no conflict of interest.

Acknowledgements

The author gratefully appreciates King Faisal University- The Deanship of Scientific Research-Vice Presidency for Graduate Studies and Scientific Research, provided funding for this work.

References

Althnaian TA. Expression of Aquaporin 1 in the Testis and epididymis of the dromedary camel (*Camelus dromedarius*) in rutting and non-rutting seasons. Journal of Camel Practice and Research 2023; 30(2):191-199.

An F and Wang J. Immunohistochemical study of aquaporin 1 and 2 in the reproductive tract of the Bactrian camel (*Camelus bactrianus*). International Journal of Morphology. 2016; 34(4):1218-22.

Arrighi S, Aralla M, Genovese P, Picabea N and Bielli A. Undernutrition during foetal to prepubertal life affects aquaporin 9 but not aquaporins 1 and 2 expression in the male genital tract of adult rats. Theriogenology. 2010a; 74(9):1661-9.

Arrighi S and Aralla M. Immunolocalisation of aquaporin water channels in the domestic cat male genital tract. Reproduction in Domestic Animals. 2014; 49(1):17-26.

Arrighi S, Bosi G, Accogli G and Desantis S. Seasonal and ageing-depending changes of aquaporins 1 and 9 expression in the genital tract of buffalo bulls (*Bubalus bubalis*). Reproduction in Domestic Animals. 2016; 51(4):515-23.

Arrighi S, Ventriglia G, Aralla M, Zizza S, Di Summa A and Desantis S. Absorptive activities of the efferent ducts evaluated by the immunolocalisation of aquaporin water channels and lectin histochemistry in adult cats. Histology and Histopathology. 2010b; 25(4):433-44.

Badran HH and Hermo LS. Expression and regulation of aquaporins 1, 8, and 9 in the testis, efferent ducts, and epididymis of adult rats and during postnatal development. Journal of Andrology. 2002; 23(3):358-73.

Brown D, Verbavatz JM, Valenti G, Lui B and Sabolić I. Localisation of the CHIP28 water channel in reabsorptive segments of the rat male reproductive tract. European Journal of Cell Biology. 1993; 61(2):264-73.

Carrageta DF, Bernardino RL, Soveral G, Calamita G, Alves MG and Oliveira PF. Aquaporins and male (in) fertility: Expression and role throughout the male reproductive tract. Archives of Biochemistry and Biophysics. 2020; 679:108222.

Da Silva N, Silberstein C, Beaulieu V, Piétrement C, Van Hoek AN, Brown D and Breton S. Postnatal expression of aquaporins in epithelial cells of the rat epididymis. Biology of Reproduction. 2006; 74(2):427-38.

Domeniconi RF, Orsi AM, Justulin LA, Leme Beu CC and Felisbino SL. Immunolocalisation of aquaporins 1, 2 and 7 in rete testis, efferent ducts, epididymis and vas deferens of adult dog. Cell and Tissue Research. 2008; 332:329-35.

Huang HF, He RH, Sun CC, Zhang Y, Meng QX and Ma YY. Function of aquaporins in female and male

reproductive systems. Human Reproduction Update. 2006; 12(6):785-95.

Ito J, Kawabe M, Ochiai H, Suzukamo C, Harada M, Mitsugi Y, Seita Y and Kashiwazaki N. Expression and immunodetection of aquaporin 1 (AQP1) in canine spermatozoa. Cryobiology. 2008; 57(3):312-4.

Klein C, Troedsson MH and Rutllant J. Region-specific expression of aquaporin subtypes in equine testis, epididymis, and ductus deferens. The Anatomical Record. 2013; 296(7):1115-26.

Lu DY, Li Y, Bi ZW, Yu HM and Li XJ. Expression and immunohistochemical localisation of aquaporin-1 in male reproductive organs of the mouse. Anatomia, Histologia, Embryologia. 2008; 37(1):1-8.

Nicotina PA, Romeo C, Arena S, Arena F, Maisano D and Zuccarello B. Immunoexpression of aquaporin-1 in adolescent varicocele testes: possible significance for fluid reabsorption. Urology. 2005; 65(1):149-52.

Nicotina PA, Romeo C, Arena S, Impellizzeri P, Antonuccio P, Arena F, Zuccarello B and Romeo G. Immunohistology of aquaporin-1 and stem cell factor-receptor in human undescended testes. Pediatric Surgery International. 2004; 20:271-5.

Oliveira CA, Carnes K, França LR, Hermo L and Hess RA. Aquaporin-1 and− 9 are differentially regulated by oestrogen in the efferent ductule epithelium and initial segment of the epididymis. Biology of the Cell. 2005; 97(6):385-95.

Oliveira RL, Campolina-Silva GH, Nogueira JC, Mahecha GA and Oliveira CA. Differential expression and seasonal variation on aquaporins 1 and 9 in the male genital system of big fruit-eating bat *Artibeus lituratus*. General and Comparative Endocrinology. 2013; 186:116-25.

Preston GM, Carroll TP, Guggino WB and Agre P. Appearance of water channels in Xenopus oocytes expressing red cell CHIP28 protein. Science. 1992; 256(5055):385-7.

Skowronski MT, Leska A, Robak A and Nielsen S. Immunolocalisation of aquaporin-1,− 5, and− 7 in the avian testis and vas deferens. Journal of Histochemistry & Cytochemistry. 2009; 57(10):915-22.

Stevens AL, Breton S, Gustafson CE, Bouley R, Nelson RD, Kohan DE and Brown D. Aquaporin 2 is a vasopressin-independent, constitutive apical membrane protein in rat vas deferens. American Journal of Physiology-Cell Physiology. 2000; 278(4):C791-802.

Yeung CH, Callies C, Tüttelmann F, Kliesch S and Cooper TG. Aquaporins in the human testis and spermatozoa–identification, involvement in sperm volume regulation and clinical relevance. International Journal of Andrology. 2010; 33(4):629-41.

Zhou Q, Clarke L, Nie R, Carnes K, Lai LW, Lien YH, Verkman A, Lubahn D, Fisher JS, Katzenellenbogen BS and Hess RA. Estrogen action and male fertility: roles of the sodium/hydrogen exchanger-3 and fluid reabsorption in reproductive tract function. Proceedings of the National Academy of Sciences. 2001; 98(24):14132-7.

DOI : 10.5958/2277-8934.2024.00008.0 *Vol 31 No 1, p 43-47*

MICROANATOMICAL STUDIES ON THE SPLEEN'S CAPSULE IN ONE HUMPED CAMEL (*Camelus dromedarius*)

Ashok Dangi, Pankaj Kumar Thanvi and Raj Kumar

Department of Veterinary Anatomy, College of Veterinary and Animal Science, Bikaner, Rajasthan University of Veterinary and Animal Sciences, Bikaner, Rajasthan, India

ABSTRACT

The aim of the study was to describe histological structure of camel spleen. The present study was conducted on 6 spleens of camel (irrespective of sex and age) procured from the apparently healthy euthanased/ dead camels (irrespective of sex and age). The spleen was covered by moderately thick fibro-elastic and muscular capsule invested by the serous peritoneal covering. The present study has shown that the capsule of the camel spleen is divided into outer connective tissue and inner smooth muscle layers constituting about 1/3 and 2/3 of the capsule thickness. Vascular and avascular trabeculae extended from the capsule, containing arteries and nerves without any trabecular veins, the latter being divided structurally into primary and secondary trabeculae. Subcapsular and peri-trabecular blood sinuses around primary and vascular trabeculae were found unique to the camel spleen.

Key words: Camel, blood analysis, haematology, lactation, physiology

Spleen is more complex than other lymphoid tissues and is an important reservoir of blood (Melvin and William, 1996). According to Bloom and Fawcett (1975), animals with a large blood volume (Equine, Ruminants and Carnivores) have scanty white pulp and a robust connective tissue. Yagil (1985) suggested that desert species of animals have larger spleen than the animals in temperate climate. Radmehr (1997) described vascular segments in the spleen of one humped camel.

The spleen is the largest organ of the lymphoid system (Smuts and Bezuidenhout, 1987) and plays an important role in immunological defence (Das *et al*, 2005). The spleen has a semi-lunar shape in camel, with a rounded dorsal extremity, separated from the main body by a narrow zone (Aichouni, 2008).

The gross, microscopic and ultrastructural details of the spleen of camel has been studied previously (Hayfaa, 2010; Abd El Aal, 1994). The histology of capsule of spleen is least studied.

The objective of present study is therefore, to describe the histological structure of capsule of dromedary spleen to understand its functionality and difference from other species.

Materials and Methods

IAEC (Institutional Animal Ethics Committee) approval:

Present investigation was approved by IAEC of CVAS, Bikaner as per CPCSEA norms vide order No. CVAS/IAEC/2017/06 dated 30/11/2017.

The present study was conducted on 6 spleens of dromedary camels (irrespective of sex and age). The cadaver spleen were obtained from the apparently healthy euthanased/dead camels (irrespective of sex and age) from Veterinary Clinical Complex, CVAS, Bikaner.

Light microscopical studies of the capsule of spleen was done to study:-

a) Distribution and types of connective tissue fibres.

b) Distribution of muscle fibres.

c) Observing the details of splenic tissues and cells.

The tissues (2mm size) were collected from different anatomical regions of spleen and preserved in 10% formal saline, Bouin's fluid and Zenker's fluid for 48hrs, 15hrs and 18hrs, respectively. These were processed for light microscopy by using paraffin

SEND REPRINT REQUEST TO ASHOK DANGI email: drashokdangi@gmail.com

of melting point 58-60°C. The paraffin blocks were sectioned to obtain 5-6µm thick sections which were subjected to the following routine histological stains to demonstrate different components of spleen.

a) Eharlich's Haematoxylin and Eosin stain for routine observation (Singh and Sulochana, 1997).
b) Gomori's method for reticulum (Luna, 1968).
c) Verhoeff's elastin stain for connective tissue fibres (Singh and Sulochana, 1997).
d) Van Gieson stain for collagen fibres (Singh and Sulochana, 1997).
e) Masson's trichrome method for collagen fibres (Singh and Sulochana, 1997).
f) Crossman's Modification of Mallory's Triple stain elastic and collagen fibres (Singh and Sulochana, 1997).
g) Gomori's method for Iron (Luna, 1968)

Results

Capsule

The spleen was covered by moderately thick fibro-elastic and muscular capsule invested by the serous peritoneal covering. Serous peritoneal layer covered the outer most layer of capsule made up of the mesothelial cells having squamous to cuboidal cells. The capsule was divided into clearly demarcated outer and inner layers (Fig 1). The cytoplasm was eosinophilic and very scanty and only the lightly basophilic nuclei were visible. The outer layer consisted mainly of connective tissue including collagen, elastic and reticular fibres with few smooth muscle cells. The inner layer was composed predominantly of smooth muscle cells supported by reticular, collagen and elastic fibres. The rich smooth muscle fibres in the capsule were arranged in three layers. An outer layer of smooth muscle fibres was arranged longitudinally parallel to the surface adjacent to the connective tissue present just below the mesothelium (Figs 2, 3, 4, 5 and 7). The middle layer fibres were arranged obliquely or transversely. The middle layer was the widest as compared to the other two layers. The muscle fibres were interwoven with the collagenous and elastic fibres (Figs 3 and 4). The reticular fibres were uniformly arranged throughout the capsule. The framework of the capsule presented mixed population of reticular, collagen and elastic fibres (Figs 2 and 3). The collagen fibres were densely arranged along with few reticular fibres just above the outer layer of the smooth muscle fibres (Fig 4). The elastic and reticular fibres were prominent in the inner most zone. A uniform layer of the reticular fibres was present being arranged longitudinally in the inner most part of the capsule. Vertically oriented fibres continued the framework of trabeculae, as compared to the fibres present in the capsule.

Trabeculae

Branching connective tissue trabeculae emerged from the innermost zone of capsule and entered into the interior of the splenic parenchyma and subdivided into smaller compartments forming a net like framework (Fig 1, 2, 5, 6). Trabeculae were uniquely divided into vascular and avascular trabeculae. The vascular trabeculae contained arteries and nerves but no veins (Fig 6). The avascular outnumbered the vascular trabeculae and were divided into primary and secondary trabeculae (Fig 6). The primary trabeculae originated from the capsule and had a similar structure to that of the inner layer of the capsule, being composed mainly of smooth muscle cells lying parallel to the longitudinal axis of the trabeculae and supported by reticular, collagen and elastic fibres. The secondary trabeculae were composed mainly of parallel smooth muscle cells with reticular fibres among them (Fig 3, 5, 6).

The large trabeculae contained arteries, veins and nerve fibres, which were surrounded by smooth muscle fibres (Fig 3, 6). The connective tissue fibres, i.e. elastic, reticular and smooth muscle fibres continued vertically from the capsule and were arranged along the longitudinal axis of the trabeculae (Fig 4, 6). The tightly packed smooth muscle fibres were oriented along its longitudinal axis (Fig 5). A wide meshwork was formed by the thin reticular fibres along with few collagenous fibres. The reticular fibres become progressively thinner in the terminal branches of the trabeculae. The elastic fibres of varying concentrations were oriented in different planes in the trabeculae (Fig 6).

Discussion

Capsule

The present study has shown that the capsule of the camel spleen is characteristically thick and divided into outer connective tissue and inner smooth muscle layers constituting about 1/3 and 2/3 of the capsule thickness, respectively. Findings of the present investigation were in accordance of Hegazi (1953), Abd El Aal (1994), Zidan *et al* (2000), Maina *et al* (2014), Bello *et al* (2016) and Alhaji *et al* (2019).

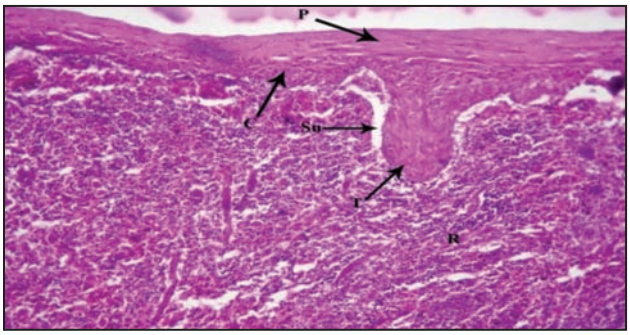


Fig 1. Section of the spleen showing outer and inner layers of capsule and peritoneal covering. C-Capsule, P-Peritoneum, T-Trabeculae, R-Red pulp, Su- Splenic sinusoid. (H&E stain, 100X).

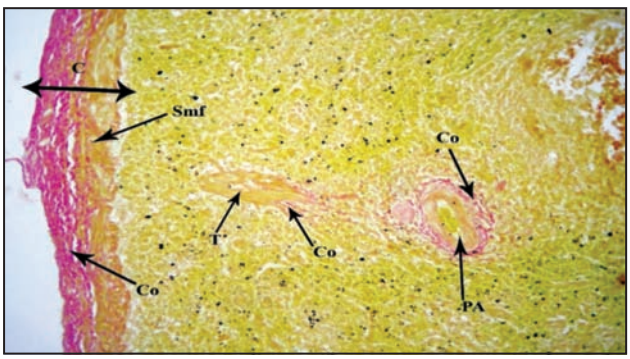


Fig 3. Section of spleen showing muscle fibres interwoven with the collagenous and elastic fibres in capsule and trabeculae. C- Capsule, Smf- Smooth muscle fibres, Co- Collagenous fibres, PA- Pulp artery, T- Trabeculae. (Van Gieson stain 40X).

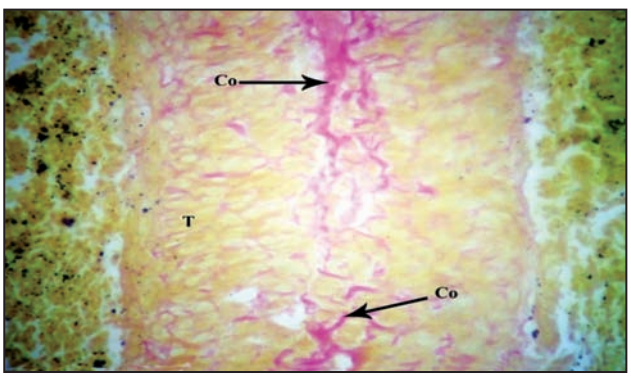


Fig 5. Section of spleen showing tightly packed smooth muscle fibres oriented along its longitudinal axis forming a wide meshwork by the thin reticular fibres along with few collagenous fibres. T- Trabeculae, Co- Collagenous fibres (Van Geison stain 400X).

The capsule was invested by serous peritoneal covering consisted of simple squamous mesothelial cells, which was in accordance with the observation of Bashir and Bernard (2015). Simple squamous mesothelial cells of peritoneal covering were irregular in shape with centrally placed spherical nucleus and attenuated strands of cytoplasm were observed in the present study.

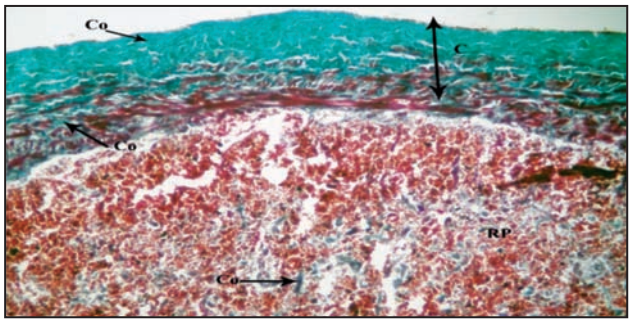


Fig 2. Section of spleen showing outer layer of capsule having collagenous fibres and collagenous fibres in RP- Red pulp. (Masson's Trichrome stain 100X).

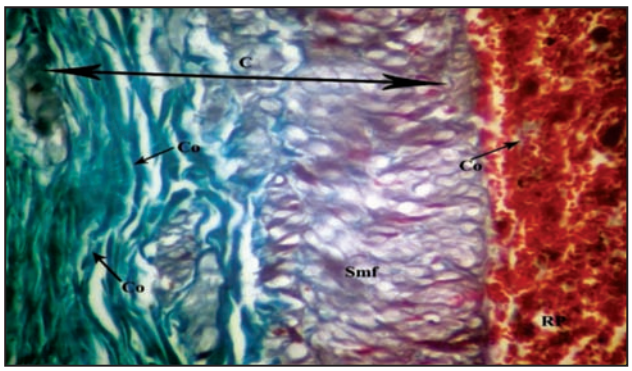


Fig 4. Section of spleen showing inner layer of capsule composed predominantly of smooth muscle cells supported by reticular, collagen and elastic fibres and collagen fibres were densely arranged along with few reticular fibres just above the outer layer of the smooth muscle fibres. C- Capsule and RP- Red pulp. Smf- Smooth muscle fibre, Co- Collagenous fibre. (Masson's Trichrome stain 400X).

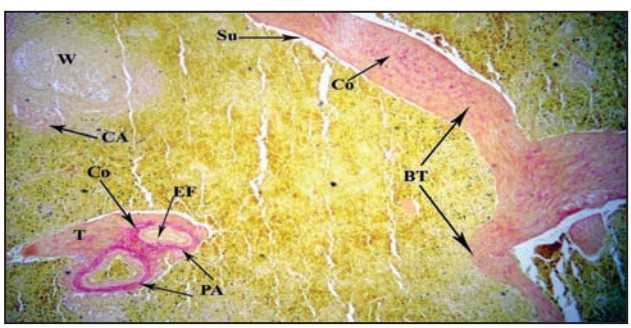


Fig 6. Section of spleen showing branching connective tissue trabeculae entered into the interior of the splenic parenchyma having vascular and avascular trabeculae. Vascular trabeculae contained arteries and nerves but no veins. Co- Collagenous fibres, EF- Elastic fibres, T- Trabeculae, W- White pulp, PA- Pulp artery, CA- Central artery, Su- Sinusoid, BT- Branch of trabeculae (Verhoeff's Elastic stain 40X).

The smooth muscle fibres were interwoven with collagenous and elastic fibres. The reticular fibres were uniformly arranged throughout the capsule as also described by Awal *et al* (1992) in indigenous cattle, Devi (2012) in Marwari goat and Jadhav *et al* (2019) in domestic pig.

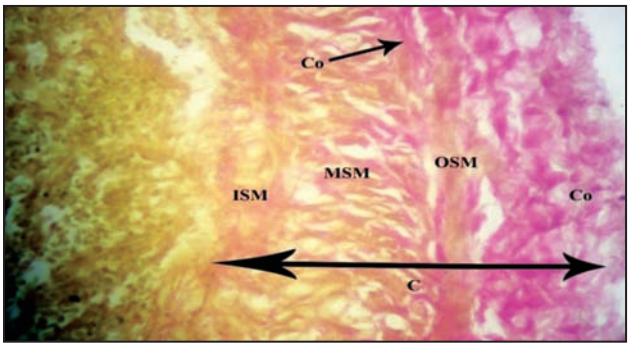


Fig 7. Section of spleen showing rich smooth muscle fibres in the inner layer of capsule arranged in three layers; outer, middle and inner. The smooth muscle fibres are arranged parallel to the surface in the outer and inner layer and oblique in the widest middle layer. T collagenous fibres in capsule, Co- Collagenous fibres, OSM- Outer layer of smooth muscle fibres, MSM- Middle layer of smooth muscle fibres, ISM- Inner layer of smooth muscle fibres, C- Capsule. (Verhoeff's Elastic stain 400X).

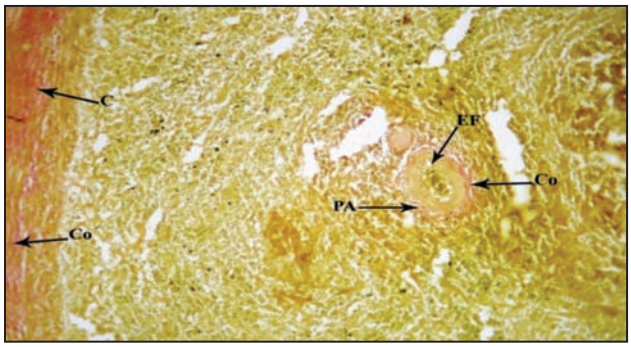


Fig 8. Section of spleen showing collagenous fibres present in capsule, artery and pulp along with some elastic fibres. Co- Collagenous fibres, PA- Pulp artery, EF- Elastic fibres, C- Capsule (Verhoeff's Elastic stain 100X).

The smooth muscle fibres were arranged in three layers; outer, middle and inner. The fibres were parallel to the surface in outer and inner layer and oblique in middle layer. These findings were in consonance with the findings of Dellmann and Brown (1987) in pig, Bajpai (1992) in goat, Thanvi (2002) in sheep and Devi (2012) in Marwari goat. The significant elastic component of the connective tissue fibres observed with trichrome stain may account for high elasticity of the spleen (Hayfaa, 2010).

The thickness of the capsule, trabeculae and concentration of smooth muscles are very important agents to make strong contraction when the body need the blood and the smooth muscle concentration may play a role in the immune reactions, and this agree with what was found by Pinkus *et al* (1986) in their study on human spleen. The arrangement of the smooth muscles in different layers in the capsule assisted smooth muscle in the trabeculae thereby contracting the spleen and to pump out the excess blood in to the circulation at the time of emergency. This simulated the finding of Banks (1981) in domestic animals that elastic fibres allowed large volume changes, whereas the contractions of smooth muscles fibres discharged the blood from the organ.

Trabeculae

The present investigation findings about trabeculae concurred, with the findings of McLeod *et al* (1964) in bovine, Raghavan (1964) in ox, Getty (1975) in horse and Maina *et al* (2014) and Alhaji *et al* (2019) in camel.

Two to three branches of the trabeculae were observed in the present study. The large trabeculae contained arteries, veins and nerve fibres, which were surrounded by smooth muscles. These findings were similar to the findings of Dellmann and Brown (1987) in pig and ruminants, Trautmann and Fiebiger (1957), Nickel *et al* (1979), Devi (2012) in Marwari goat, Gnanadevi *et al* (2019) in sheep and goat and Rahmoun *et al* (2019) in rabbit spleen.

Conflicts of Interest

The authors declare no conflict of interest.

References

Abd El Aal E. Some histological and histochemical studies on the spleen of the dromedary camel (*Camelus dromedarius*). Masters Thesis (MSc), Faculty of Veterinary Medicine Moshtohor, Zagazig University, Egypt. 1994.

Aichouni A. The spleen in the one humped camel (*Camelus dromedarius*). Anatomical and histological study. Egypt Journal of Applied Science. 2008; 23(A):36-47.

Alhaji ZJ, Adamu SS, Mohammed BM, Mbaya PY, Ibrahim AG, Tomar P and Faruk D. Morphology, morphometry and histogenesis of the prenatal dromedary (*Camelus dromedarius*) spleen. Macedonian Veterinary Review. 2019; 42(2):141-149.

Awal MA, Shahjahan M, Mia AK, Islam MN and Khan MAB. Histology of the spleen of indigenous cattle (*Bos indicus*) in Bangladesh.Bangladesh Veterinarian. 1992; 9(1-2): 98-102.

Bajpai UK. Gross, Histological and certain histochemical observations on the spleen of the goat (*Capra hircus*). Masters Thesis (M.V.Sc.), CS Azad University of Agriculture and Technology, Kanpur, India. 1992.

Banks WJ. Applied Veterinary Histology: Williams and Wilkins, Baltimore/London. 1981; pp 327-339.

Bashir MJ and Bernard F. Normal Pattern of Camel Histology. UTF/SAU/021/SAU, Food and Agriculture Organisation, Ministry of Agriculture of the United Nations Kingdom of Saudi Arabia. 2015.

Bello A, Onu JE, Fawaz AM, Hena SA, Sonfada ML, Umaru MA and Shehu SA. Prenatal development of the

spleen of one-humped camel (*Camelus dromedarius*): A comparative histological study. Scholarly Journal of Agricultural Science. 2016; 6(8):263-269.

Bloom W and Fawcett DW. A Text Book of Histology. WB Saunders Company, Philadelphia. 10th Ed. 1975; pp 487-502.

Das SK, Alam MS, Islam MN and Awal MA. Histology of the spleen of indigenous dog (*Canis familiaris*) of Bangladesh. Bangladesh Journal of Veterinary Medicine, 2005; 3(1):59-61.

Dellmann HD and Brown EM.Text Book of Veterinary Histology. Lea and Febiger Philadelphia. London 3rd Ed. 1987; pp 176-182.

Devi H. Gross and histological studies on the spleen of marwari goat (*Capra hircus*). Masters Thesis (MVSc), Rajasthan University of Veterinary and Animal Sciences, Bikaner, Rajasthan, India. 2012.

Getty R. Sisson and Grossman's-The Anatomy of the Domestic Animals. WB Saunder Company, Philadelphia (Toronto). 5th Ed. 1975; Vol. I. pp 180, 630-632, 1063, Vol.II. pp 1358, 1359, 1669, 1670.

Gnanadevi R, Senthilkumar S, Kannan TA and Ramesh G. Comparative histoarchitectural study of splenic components in sheep and goat. International Journal of Current Microbiology and Applied Sciences, 2019; 8(5):1387-1394.

Hayfaa AA. Histological and histometric study on the spleen of Iraqi camel (*Camelus dromedarius*). Emirates Journal of Food and Agriculture. 2010; 22(1):65-70.

Hegazi AEH. The spleen of camel compared with other domesticated animals and its microscopic examination. Journal of the American Veterinary Medical Association. 1953; 122:182-184.

Jadhav KA, Waghaye JY, Thakur PN, Kadam SD and Palaskar MS. Comparative light microscopic study of splenic stroma in male and female local domestic pig (*Sus scrofa domesticus*). Journal of Entomology and Zoology Studies. 2019; 7(2):898-903.

Luna LG. Manual of Histological Staining Methods of Armed Force Institute of Pathology. McGraw-Hill Book Company, New York. 3rd Edn. 1968; pp 87-88, 94-95.

Maina MM, Usende IL, Igwenagu E, Onyiche TE, Yusuf ZM and Ntung NO. Gross, histological and histomorphometric studies on the spleen of one humped camel (*Camelus dromedarius*) found in the semi-arid region of North Eastern Nigeria. Journal of Veterinary Advances. 2014; 4(10):703-711.

McLeod WM, Trotter DM and Lumb JW. Bovine Anatomy. Burgess Publishing Company, Minneapolis. 2nd Ed. 1964; pp 118-119.

Melvin JS and William OR. Duke's Physiology of Domestic Animals. Panima Publishing Corporation New Delhi (India). 11th Ed., 1996; pp 40, 256.

Nickel R, Schummer A and Seiferle E. The Viscera of the Domestic Mammals. Verlag Paul Parey, Berlin Hamburg. 2nd Ed. 1979; pp 204-210.

Pinkus GS, Warhol MJ, O'Connor EM, Etheridge CL and Fujiwara K. Immunohisto-chemical localisation of smooth muscle myosin in human spleen, lymph node, and other lymphoid tissues. Unique staining patterns in splenic white pulp and sinuses, lymphoid follicles, and certain vasculature, with ultrastructural correlations. American Journal of Pathology. 1986; 123:440-53.

Radmehr R. Vascular segments in the spleen of one humped camel (*Camelus dromedarius*). Journal of Camel Practice and Research. 1997; 4:45-46.

Raghavan D. Anatomy of the ox. Indian Council of Agricultural Research, New Delhi. First Ed. 1964; pp 377-379.

Rahmoun DE, Fares MA, Bouzebda-Afri F and Ben Driss K. Anatomical and histological study of the rabbit spleen development in the postnatal period in Algeria. Online Journal of Animal and Feed Research. 2019; 9(2):44-50. www.ojafr.ir

Singh UB and Sulochana SA. Handbook of histological and histochemical technique. Premier Publishing House, Hyderabad. 1997; pp 8-57.

Smuts MMS and Bezuidenhout AJ. Anatomy of the Dromedary. Clarendon Press, Oxford. 1987; pp 133, 156, 167.

Thanvi P. Gross and histological studies on the spleen of sheep (*Ovis aries*). Masters Thesis (MVSc), Rajasthan University of Veterinary and Animal Sciences, Bikaner, Rajasthan, India. 2002.

Trautmann A and Fiebiger J. Fundamentals of Histology of Domestic Animals. Comstock Publishing Associates, Ithaca, New York. 1957; pp 129-135. Translated and revised by Hable, R.E. and Biberstein, E.L.

Yagil R. The Desert Camel. Karger, New York. 1985; pp 80.

Zidan M, Kassem A, Dougbag A, Ghazzawi EE, Mohamed Abd El Aziz1 and Reinhard P. The spleen of the one humped camel (*Camelus dromedarius*) has a unique histological structure. Journal of Anatomy. 2000; 196, pp 425-432.

SHORT COURSE IN CAMEL REPRODUCTION

Dr. Lulu Skidmore organised a short course in camel reproduction at Camel Reproduction Centre, Dubai, United Arab Emirates from March 4th – 6th 2024. It was aimed at veterinary surgeons and animal scientists who have an interest in camel reproduction with special emphasis on embryo transfer and artificial insemination. The course was taught in English and the programme included lectures and practical sessions. The lectures included camel reproductive physiology, embryo recovery and transfer, management of recipients, semen collection, handling and analyses, artificial insemination, assisted reproductive techniques IVF, ICSI and freezing of semen and embryos. Practicals included ultrasonography of female reproductive tract, embryo flushing, recovery and transfer, embryo handling and evaluation, ultrasonography of male reproductive tract, semen collection and handling and AI, semen analyses and staining techniques, semen freezing, embryo vitrification.

NACROA DELEGATION VISITS AND COLLABORATES IN INDIA AND MOROCCO

NACROA Secretary General Valeri Crenshaw and Education Chairperson Doug Baum, alongside NACROA members Guy Seeklus, Eric Souders, Dr. Keely Smith, Jennifer Lagusker, and Wendy Fife, attended the "Cross Cultural Experience Sharing on Camel Conservation and Wellbeing" at a workshop held at Nagaur on 16-17 Febuary 2024. Crenshaw extended words of welcome to the attendees and provided an overview of NACROA's activities in India and Baum presented on camel well being and how caring for the camel caretakers was vital to improve the well being of camels. While in India, the NACROA delegation visited Rajasthan University of Veterinary and Animal Sciences (RAJUVAS), Bikaner as well as the National Research Centre on Camel (NRCC).

In March, a NACROA delegation attended Hassan II University of Casablanca, Morocco where Crenshaw and Baum presented at the 5th International Conference on "Scientific, Socio-cultural and Tourist Research on the Dromedary" in Ben M'Sick Faculty of Sciences. Crenshaw presented "Raising Camels in Cattle Country" and Baum presented "Realising the Potential of Camels and Tourism." The conference was organised and hosted by Professor Mohammed Elkhasmi and Professor Mohamed Farh. A cooperation convention between NACROA and Hassan II University of Casablanca was signed to promote fruitful cooperation for the well being of the camel. While in Morocco, NACROA met with international animal welfare organisation SPANA, making a donation of nylon camel halters for working camels in the Marrakech region. SPANA and NACROA have made an agreement to continue working together to further camel welfare in Morocco.

DOI : 10.5958/2277-8934.2024.00009.2 *Vol 31 No 1, p 49-55*

EXISTING MANAGEMENTAL PRACTICES OF CAMEL FARMERS IN SEMI-ARID REGION OF RAJASTHAN

Santosh Kumar Rao[1], Navav Singh[1], Sanjita Sharma[1], Poonam Lata[2], Ashok Baindha[3], Vipin Chandra[1] and Govind Singh Dhakad[4]

[1]Department of Livestock Production Management, [3]Department of Department of Veterinary Extension Education, [4]Department of Animal Breeding and Genetics, Post Graduate Institute of Veterinary Research, Jaipur, Rajasthan, India
[2]Department of Parasitology, College of Veterinary Animal Sciences, Navania, Udaipur, Rajasthan, India

ABSTRACT

The present study was done to understand the existing managemental practices of camel farmers in the semi-arid region of Rajasthan. A total of 70 respondents, 35 each were randomly selected from Jaipur and Ajmer districts, and interviewed. Desired information was collected in the questionnaire. The collected data were tabulated and subjected to various statistical methods to draw meaningful inferences. The result represented that the majority of camel reared in loose housing system (71.42% and 80%) and were devoid of any puckka floor (82.40% and 87.50%); roof (95.00% and 87.50%); wall (90.00% and 80%); feeding manger (71.42% and 66.66%); bedding material (96.15 and 80%); water troughs (59.25%, 85%); drainage system (77% and 80%) in Jaipur and Ajmer district, respectively. The most common feeding practice was browsing + stall feeding (65.73% and 62.85%); the mode of purchase for feed was direct from market (71.42% and 85.71%); provided additional feed (60% and 71.42%); and the source of feed was purchased (65.73%, 62.28%) in Jaipur and Ajmer districts, respectively. All camel farmers adopted natural service followed for breeding in Jaipur and Ajmer. In Ajmer, more respondents were aware of the oestrus sign (54.29%) as compared to Jaipur (40.00%); providing extra allowance for pregnant animals in Jaipur and Ajmer (65.72% and 60.00%), extra care for pregnant animals (65.72% and 54.29%), breeding season (Oct-March and Nov-March) in Jaipur and Ajmer districts, respectively. The present study revealed that most camel farmers used traditional management practices in both districts and it required training regarding scientific management practices of a camel for efficient utilisation of resources and achieving maximum production through camel rearing.

Key words: Breeding practices, camel farmers, existing managemental practices, housing practices, semi arid region

The typologies of camel farming systems may vary from the more traditional farms in the desert, with a nomadic lifestyle, to farms managed by owners living in the city with modern commercial purposes (Abdallah and Faye, 2013). The structural and management characteristics of facilities or practices, such as housing, feeding, breeding, and health management could affect several aspects of camel welfare as well as production. An economic feeding schedule adheres to maximum and optimal utilisation of the locally available feed resources (Kumari *et al,* 2023a). Thus, the description of the camel rearing conditions at markets and farms is of considerable importance not only to understand the welfare issues of both animals and farmers but also to evaluate current trends in this livestock sector (Abdallah and Faye, 2013; Menchetti *et al,* 2021). To enhance camel welfare as well as the income of camel owners for the increased interest of people towards rearing of camels, future studies are needed to introduce standard management methods and facilities for camel keeping and farming. It is, therefore, necessary for more studies on existing or traditional management practices of camel to introduce ideal management practices appropriate to the ecosystem and tradition for sustainable camel production.

Materials and Methods

The present study was conducted in two selected districts *viz*. Jaipur (26.9°N, 75.8°E) and Ajmer (26.4499°N, 75.6399°E) of Rajasthan. The selected respondents were interviewed and the desired information was collected in the developed questionnaire. Camel farmers who owned camels and being familiar with camel husbandry were selected from each district based on camel holding size as follows:

(i) Small holding - (1-2 camel) – Minimum 20 respondents.

(ii) Medium holding - (2-5 camel) - Minimum 10 respondents.

SEND REPRINT REQUEST TO SANTOSH KUMAR RAO email: drnavavsinghdhaker@gmail.com

(iii) Large holding (more than 5 camels) -Minimum 05 respondents.

A total of 70 camel farmers, 35 farmers from each district were selected to take part in the study. The data were collected with the help of a projected structured interview schedule by holding a personal interview with camel keepers by the researchers. The collected data was compiled, tabulated and analysed as per given objectives of the study with the help of appropriate statistical methods

Results and Discussion

The important prevailing camel husbandry practices *viz*. housing, feeding, breeding, health care and miscellaneous in the study area have been summarised in Tables 1, 2, 3, 4 and 5.

Housing practices: The present study observed that the majority of camel keepers kept their camels under loose housing systems (71.42% and 80%) and did not construct any type of floor (82.40% and 87.50%) in Jaipur and Ajmer. Normally camel houses did not have roofs (95.00% and 87.50%) and walls (90.00% and 80%) as the majority of camel keepers kept them in open areas or under trees. These findings are also in conformity with Rajput and Tripathi (2005), Bhakat and Pathak (2009) who found that camels were kept in shedless open areas with sandy floor for camels in Rajasthan. Similarly, Faraz *et al* (2019) reported that majority of camels are reared in open housing systems (60%) while few (40%) in semi-open housing systems.

Manger feeding and water trough: It was revealed that the majority of camel keepers did not use manger for feeding of camels in Jaipur and Ajmer (71.42% and 66.66%) whereas provision of water trough for drinking was present in camel houses in Jaipur (59.25%) but in Ajmer, majority of camel houses (85%) were without water troughs. Similar findings were observed by Dhawal *et al* (2020) who found that feeding in manger was less common practice and the majority of camel owners were using plastic or bamboo basket/old tyres (wheels) of the cart as feeding trough (movable). Bhakat and

Table 1. Housing practices in the study area Jaipur and Ajmer.

Variables		Jaipur	Ajmer
		Per cent (%)	Per cent (%)
Type of house	Loose housing	71.42	80.00
	Extensive/Migration	28.57	20.0
Floor	Pucca	17.59	12.50
	Kutcha	82.40	87.50
Type of Roof Material	Conventional	05.00	12.50
	No Roof	95.00	87.50
Material used in walls	Brick with mud	03.00	00.00
	Kutcha	07.00	20.00
	No Walls	90.00	80.00
Manger Feeding	Yes	28.57	33.33
	No	71.42	66.66
Bedding material	Yes	09.09	20.00
	No	96.15	80.00
Presence of Watering troughs	Yes	59.25	15.00
	No	40.74	85.00
Drainage System	Efficient	8.00	12.00
	Non – efficient	15.00	08.00
	No Drainage System	77.00	80.00

Table 2. Feeding practices in the study area Jaipur and Ajmer.

Variables		Jaipur	Ajmer
		Per cent (%)	Per cent (%)
Feeding practices	Stall feeding	22.85	05.73
	Browsing feeding	11.42	31.42
	Browsing +stall feeding	65.73	62.85
Mode of Feed Purchase	Direct	71.42	85.71
	Indirect	28.58	14.29
Additional feed added	Yes	60.00	71.42
	No	40.00	28.58
Source of feed	Locally available forages/ weeds	34.27	62.28
	Purchased Feed	65.73	37.72
Preserved feed used	Yes	80.00	74.28
	No	20.00	25.72
Frequency of feeding	Once	22.75	11.42
	Twice	60.00	65.73
	Other	17.15	22.85
Concentrate feeding	Yes	91.42	77.14
	No	8.58	22.86
Concentrate type	Purchased concentrate	24.27	61.70
	Homemade concentrate	75.73	38.30
Extra Concentrate feeding for lactating camels	Yes	68.58	71.43
	No	31.42	28.57
Extra Concentrate feeding for breeding male	Yes	65.71	14.29
	No	34.29	85.71
Mineral mixture used	Yes	91.42	68.57
	No	8.58	31.43

Pathak (2009) found the majority of households were using movable feeding troughs but fewer households constructed mangers in camel houses.

Feeding Practices: The present study revealed that most of the camel keepers adopted browsing + stall feeding (65.73% and 62.85%) in Jaipur and Ajmer. These results aligned with Dhawal *et al* (2020) who found that the majority of respondents in Bikaner (90%) and Jaisalmer (75%) were following both stall feeding and grazing on pasture land (semi-intensive). Bhakat and Pathak (2009) reported that the feeding practices were different and depended on the category of the farm. Small-category farmers adopted mostly browsing practices while medium farmers adopted both types of feeding practices (browsing + stall feeding) and large farmers adopted mostly stall feeding for camels as per their convenience. Faraz *et al* (2019) reported that the majority of camels were reared in stall and browsing feeding practices.

Mode of purchase and source of feed: It was observed that the most common mode of purchasing feed was direct from the market in Jaipur and Ajmer (71.42% and 85.71%). It was indicated that camel keepers were procuring feed through purchasing in Jaipur (65.73%) but in the case of Ajmer, locally available forages/weeds (62.28%) were used for feeding camel. The practice of using preserved feed for camel was common in Jaipur and Ajmer (80% and 74.28%, respectively). According to Dhawal *et al* (2020), there was insufficient grazing pasture and owned farm products to meet the daily requirement of feed for camels due to which about 93 per cent of respondents were compelled to purchase fodder from the market.

Provision of concentrate feed: The data showed that most camel keepers provide concentrate feed to camels in Jaipur and Ajmer (91.42% and 77.14%). However, homemade concentrate feed was common in Jaipur (75.73%) but in the case of Ajmer purchased concentrate was common (61.70%). Bhakat and Pathak (2009) also reported that about 18% of farmers were providing concentrate as per scientific recommendations.

Extra concentrate feed for lactating camel and breeding males: It was also observed that camel keepers provided extra concentrate feed for lactating camel in Jaipur and Ajmer (68.58% and 71.43%). Extra concentrate feed was provided for breeding males in Jaipur (65.71%) but in the case of Ajmer,

Table 3. Breeding practices in the study area Jaipur and Ajmer.

Variables		Jaipur	Ajmer
		Per cent (%)	Per cent (%)
Breed of camel	Non- descript	92.50	63.00
	Descript	7.50	37.00
Mode of Breeding	Natural service	100.00	100.00
	Artificial insemination	0	0
Mode of Breeding	Yes	40.00	54.29
	No	60.00	45.71
Aware with oestrus sign (Heat detection)	Yes	20.00	28.57
	No	80.00	71.43
Castration practices adopted	Yes	65.72	60.00
	No	34.28	40.00
Extra allowance for pregnant animals	Yes	65.72	54.29
	No	34.28	45.71
Care of pregnant animals	Small	Dec-March	Nov-Feb
	Middle	Dec-Feb	Dec-Jan
Breeding season	Large	Oct-March	Nov-March
	Small	37	35
Age at 1st mating/ heat (months)	Middle	36.60	35
	Large	31.89	29.72

Table 4. Health care practices in the study area Jaipur and Ajmer.

Variables		Jaipur	Ajmer
		Per cent (%)	Per cent (%)
Deworming schedule followed	Regular	25.71	0.00
	Irregular	48.57	82.85
	Never	25.71	17.14
Regular vaccination adopted	Yes	34.28	82.85
	No	65.71	17.14
Veterinary aid available	Satisfactory	42.85	82.85
	Poor	57.14	17.14
Calf mortality	upto 1 month	48.57	22.85
	1-3 month	42.85	65.71
	Above 3 month	8.50	8.50
Prevalence of common diseases	Diarrhoea	35.00	25.80
	Skin disease	28.33	25.80
	Blot	25.00	40.32
	Unknown	11.66	8.08
Isolation of sick animals	Yes	60.00	40.00
	No	40.00	60.00
Indigenous method of treatment followed	Yes	15.62	53.15
	No	84.38	46.85

Table 5. Distribution of respondents according to their milking practices in the study area.

Personal Attributes		Jaipur	Ajmer
		Average Mean	Average Mean
Selling of camel milk (Rs./L)	Regular Basis	38	23
Time and milking technique	Regular Basis	5-7 am 5-7 pm Shiftpan	5-7 am 5-7 pm Bucket hanging
Milking method	Full hand	16.33	32.01
	Knuckling	78.34	65.33
	Stripping	5.34	2.66
	Machine Milking	0.00	0.00
Lactation Period/ Length (Months)	Regular Basis	16-18	14-16

it was uncommon (85.71%). Bhakat and Pathak (2009) observed that the concentrates were also fed to breeding camels only during the breeding season once a month in Bikaner. Rajput and Tripathi (2005) reported that farmers provide concentrate feed for lactating camels at weekly intervals immediately after parturition 41.66% and 25% of the families at Jaipur and Ajmer, respectively. Concentrates were also fed to breeding camels only during the breeding season once a month by half of the respondents.

Provision of mineral mixture: The results showed that awareness about the feeding of the mineral mixture was observed in the majority of camel keepers in Jaipur and Ajmer districts (91.42% and 68.57%). Dejene (2015) found that mineral supplementation was provided for almost all categories of camels.

Common green and dry forage: The most common green forages are bajara (*Pennisteum glaucum*), jowar (*Sorghum bicolor*), maize (*Zea mays*), lucerne (*Medicago sativa*) and berseem (*Trifoluim alexandrium*), dry forages are wheat straw (*Triticum aestivum*), barley straw (*Pennisteum glaucum*), green straw, oat straw (*Avena sativa*) and zao (*Ziziphus jujuba*), top forages are ardu (*Ailanthus excelsa*), neem (*Azadirachta indica*), ber (*Zizyphus jujaba*) and khejri (*Prosopis cineraria*), trees are khejri, neem, babul (*Acacia arabica*), rohida (*Tecomella undulata*) and subabul (*Leucaena leucocephala*) in Jaipur and Ajmer. Dhawal *et al* (2020) observed that camels were fed on bushes and trees like khejari, jharberi (*Ziziphus nummularia*), neem, jaal (*persica oleoides*), tali (*Erythrophleum suaveolens*), kair (*Capparis decidua*) and fog (*Holcus lanatus*). Camel owners were giving guar or cluster bean fodder local name phalgati, moth chara (*Heliocheilus lupatus*), wheat straw, bajra stem and groundnut chara as roughage. In concentrate feeding, they were giving cotton seed cake, til cake (*Sesamum indicum*), groundnut cake (*Arachis hypogaea*), sunflower cake (*Helianthus annuus*), guar (*Cyamopsis tetragonoloba*), moth churi, gram churi (*Cicer arietinum*), barley (*Hordeum vulgare*) and bajra in Bikaner and Jaisalmer. Rajput and Tripathi (2005) reported that about 50% of the respondents fed bajra as concentrate followed by moth and guar by 36.67 and 13.33%, respectively, during winter. Above 55% of respondents were providing moth during both summer and rainy seasons. Moth chara was one of the major roughages provided to camels in all the 3 seasons by the majority of the Raikas follbwed by mufali chara and guar phalgati, the other common roughages. Loon (leaves) of desert tree khejri (*Prosopis cineraria*) were fed to animals by the majority of the families in both winter and rainy seasons. However, phog (*Calligornum polygononides L.*) is an important bush, which was also given by about 58% of the respondents during summer. About 33.0, 17.0 and 8.0% of Raikas were also feeding ker (*Capparis deciduas*) to camel during winter, summer and rainy season, respectively.

Breeding Practices: All camel keepers adopted natural service (100%) in Jaipur and Ajmer districts. Rajput and Tripathi (2005) reported that the artificial insemination practice in camel was absent in the Bikaner district. The results conformed with Saini *et al* (2007), Mehta *et al* (2007), Singh *et al* (2009) and Faraz *et al* (2019).

Awareness of oestrous sign: The result indicated that the majority of camel keepers were not aware of the oestrus signs in camels at Jaipur (40.00%) but in the case of Ajmer respondents were aware of the oestrus signs (54.29%). Rajput and Tripathi (2005) reported that the raikas followed different common traditional practices for the identification of heat in she-camels. The majority of the respondents (68.34%) were identifying heat in female camels by observing slimy discharge from the vulva. About 30% of Raika reported that refusal to eat and frequent micturition habits in females were the other symptoms of heat identification.

Castration practice: Castration practice was not common among farmers in Jaipur and Ajmer (80.00% and 71.43%) districts. These results were aligned with Woldearegay *et al* (2015) who found that 70.0% of the respondents did not prefer to castrate their camels.

Extra care and concentrate allowance: It was observed that camel keepers provide extra care and

concentrate allowance for pregnant she-camel (65.72% and 54.29%) and (65.72% and 60.00%) in Jaipur and Ajmer districts, respectively. Similar findings were observed by Rajput and Tripathi (2005) and Bhakat and Pathak (2009), who reported that most of the farmers provide extra ration during the advance stage of pregnancy and give extra care during parturition.

Breeding season: Results obtained indicated that the heat in camels was evidenced during winter (rutting period) in Jaipur and Ajmer (Oct-March and Nov-March). The breeding (rutting) period in the camel ranged from November to March (Rajput and Tripathi, 2005; Faraz *et al,* 2019).

Age at first mating: It was observed that the age of first mating in female camel was 30-37 months in Jaipur and Ajmer districts. Dejene (2015) reported that the age at first mating in female camel was 48 – 72 months.

Health care practices

Deworming and Vaccination: Data represents that the majority of camel farmers in the Jaipur district were more aware of deworming schedule than Ajmer. Nearly 25.71 per cent of farmers regularly and 48.57 per cent irregularly followed the deworming schedule whereas in Ajmer district majority of the farmers (82.85 per cent) irregularly followed the deworming schedule. For vaccination practices, 65.71 per cent did not follow regular vaccination in Jaipur. Contrarily, in the Ajmer district, 82.85% of camel farmers followed a regular vaccination schedule. Padalino *et al* (2021) reported that most of them carried out deworming and ectoparasites treatments by themselves ($p < 0.001$) while over 70% did not vaccinate their camels ($p < 0.001$). Abdallah and Faye (2013) reported that the majority of the camel owners did not vaccinate camels against pox (jedari) in the study area of Saudi Arabia. Dejene (2015) found that vaccination was not rendered for the camel in the study area.

Veterinary aid: The results indicated that veterinary services were poor in Jaipur (57.14%) but in the case of Ajmer, camel farmers were satisfied with veterinary services (82.85%). Dhawal *et al* (2020) reported that in 25 per cent of respondents in the Bikaner district and 50 per cent of respondents in the Jaisalmer district, the veterinary facilities were available in their village. However, the majority (62.50%) of respondents from both districts reported the lack of a veterinary facility in their village. Dejene (2015) found that the majority (81.32%) of camel keepers did not have access for veterinary services. Osman *et al* (2015) reported that most camel owners (70%) responded that there is no veterinary service and the majority of them (80%) mentioned that the veterinary service was provided by the private sector while 20% mentioned that the veterinary service was provided by the government.

Calf mortality: The data showed that the majority of calf mortality was observed, up to 1st month in Jaipur (48.57%) but in the case of Ajmer, common in 1-3 months (65.71%). Faraz *et al* (2019) reported 24% calf mortality in camels. Awoke and Ali (2015) found that the overall percentage of pre-weaning mortality for camels was 61.5%.

Prevalence of common diseases: It was also revealed that the most common prevalent diseases in camels were diarrhoea in Jaipur (35.00%) and blot (40.32%) in Ajmer area. Awoke and Ali (2015) reported that all the agro-pastoral and pastoralists paid particular attention to diarrhoea, describing it as a serious killer of very young camel calves.

Indigenous method of treatment: The data indicated that the majority of farmers did not use the indigenous method of treatment in Jaipur (84.38%) but in the case of Ajmer, the majority of camel farmers (53.15%) used indigenous methods. These findings were in accordance with Dhawal *et al* (2020) who reported the majority of respondents in Bikaner (55%) and Jaisalmer (50%) districts treated medicinal problems by self among their camels followed by a veterinarian in Bikaner (31.67%) and Jaisalmer (43.33%). Lamuka *et al* (2017) reported that most of the camel farmers self-medicated their camels and chose drugs based on their own experience or the advice of the shop attendant in the study area of Kenya. Abdallah and Faye (2013) reported that about 19% of camel farmers used traditional medicine to treat sick camels, particularly parasite diseases such as mange or ringworm in Saudi Arabia. Awoke and Ali (2015) reported that agro-pastoral and pastoralists from all the districts attempted to control diarrhoea using different traditional methods to treat diarrhoea by giving the calf black tea and depriving it of milk, depriving the calf of colostrums for very young ones, oral administration of sheep and goat fat, salted water.

Milking practices: The present study also revealed that the average price of camel milk on a regular basis in Jaipur and Ajmer was Rs 38 and 23, respectively. The average time for complete milking in Jaipur and Ajmer was 5-7 am and 5-7 pm, but the milking technique varied. They used the Shift pan method and Bucket hanging method, respectively.

The most common method of milking was Knuckling in Jaipur and Ajmer (78.34% and 65.33%). The average lactation period/length (month) in Jaipur and Ajmer was 16-18 months and 14-16 months. Bhakat and Pathak (2011) reported that most of the farmers (78%) were milking their camel through knuckling method because it helps in squeezing out maximum milk from the udder as per farmers' perception. Others (22%) practiced the hand-stripping method. Milking was done in a standing position by farmers. Usually, the milker stands on the left side of a camel on one leg, while the thigh of the other leg was used to place the milking container over it. Tandon *et al* (1998) reported that the lactation length in camel varied from 8 to 9 months and it could last for 16 months. Shishay and Mulugeta (2018) observed that the lactation length in camel varied from 9 to 16 months. Lactation length is shortened when producers have plenty of feed for the calf. Lactation length is extended to prevent pregnancy and then to carry on to continue milk production for household consumption as well as to safeguard the camel calf (Yohannes *et al*, 2007), and if the extent of demand for milk by the owner advanced than ever and there is better feed availability for the animal (Simenew *et al*, 2013). Mahamed *et al* (2015) reported that the milking frequency of camel was 2-3 times per day. Similarly, Osman *et al* (2015) observed that the majority of camel owners (61.7%) milked two times per day and the lactation period of camel varied from 8 months to 14 months.

Conclusion

The present study revealed that most camel farmers use traditional management practices in both districts and its required training regarding scientific management practices of camel for efficient utilisation of resources and achieving maximum production through camel rearing.

Acknowledgements

The authors acknowledge the gratitude to the Post Graduate Institute of Education and Research (PGIVER), RAJUVAS for providing facilities for conducting research work.

Conflicts of Interest

The authors declare no conflict of interest.

References

Abdallah HR and Faye B. Typology of camel farming system in Saudi Arabia. Emirates Journal of Food and Agriculture. 2013;2(5):250-260.

Awoke K and Ali SM. Traditional Husbandry Practices and Major Challenge of Young Stock (Camel Calf) in Fafen Zone, Ethiopian Somali Regional State. Journal of Environmental and Analytical toxicology. 2015;(5): 321.

Bhakat C and Pathak KML. Socio-economic aspects of dromedary camel management in hot arid desert ecosystem. Indian Journal of Animal Sciences, 2009; 79(7):700-05.

Bhakat C and Pathak KML. Important factors affecting sustainable livelihood of camel dairying in changing scenario of desert ecosystem. Indian Journal of Animal Sciences. 2011; 81(1):48–51.

Dejene TG. Husbandry Practices and Utilisation of Camel Products in Borana Zone of Southern Oromia, Ethiopia. Science Research. 2015; 3(4):191-197.

Dhawal KK, Rajput DS, Sharma NK, Mishra P and Kumari, M. Study on management prcatices of camel in arid zone of Rajasthan. International Journal of Livestock Research. 2020; 10(10):218-224.

Faraz A, Waheed A, Yaqoob M and Mirza RH. Camel Production Profile in Desert Ecosystem of Thal, Punjab. Sindh University Research Journal -Science Series. 2019; 51(01):45-52.

Kumari S, Sharma S, Sahoo A, Sawal RK, Singh N and Ahari A. Effect of tanniferous tree leaves in Camel's diet on milk yield and quality. Journal of Camel Practice and Research. 2023a; 30(1):73-79.

Lamuka PO, Njeruh FM, Gitao GC and Abey KA. Camel health management and pastoralists' knowledge and information on zoonoses and food safety risks in Isiolo County, Kenya. Pastoralism Research Policy and Practice. 2017; 7:20.

Mahamed A, Haji A, Beriso K and Gebeyew K. Small camel holder camel milk production performance in Jijiga district, Somali regional state Eastern Ethiopia. Journal of Veterinary Science and Technology 2015; 6:267.

Mehta SC, Bhardwaj B and Sahani MS. Status and conservation of Mewari and Jaisalmeri camels in India. Animal Genetic Resources Information, 2007; 40:87-101.

Menchetti L, Zappaterra M, Costa LN and Padalino B. Application of a protocol to assess camel welfare: Scoring system of collected measures, aggregated assessment indices, and criteria to classify a pen. Animals. 2021; 11:494.

Osman AM, Abdelkreim M, Abukashawa SMA and Ibrahim MT. Studies on camel's feeding and utilisation of camel's milk in buttana area, Gaderif State, Sudan. Journal of Advances in Dairy Research. 2015; 3:141.

Padalino B, Abdelali Z, Monaco D, Freccero F and Menchetti L. Dromedary camel health care practices reported by caretakers working at a permanent market. Emirates Journal of Food and Agriculture. 2021; 33(4):348-361.

Rajput DS and Tripathi H. Camel husbandry practices followed by Raikapastoralists under semi-intensive system in Bikaner district of Rajasthan. Indian Journal of Animal Sciences. 2005; 75(11):1307-13.

Saini N, Singh N and Kiradoo BD. Field management survey study of camel in western Arid zone of Rajasthan. Journal of Veterinary Practitioner. 2007; 8(1):88-91.

Shishay G and Mulugeta F. Camel milk production, prevalence associated risk factor of camel mastitis in Aysaitaworerda Afar regional state, North East Ethiopia. ARC Journal of Animal and Veterinary Science. 2018; 4(3):17-37.

Simenew K, Dejen T, Tesfaye S, Fekadu R, Tesfu K and Fufa D. Characterization of Camel Production System in Afar Pastoralists, North East Ethiopia. Asian Journal of Agricultural Sciences. 2013; 5(2):16-24.

Singh BP, Sharma MC, and Tiwari R. (2009). Feeding resources and management among poor livestock keeper: A field study in linkage villages. The Indian Journal of Animal Sciences. 2009; 79(12):1263-1264.

Tandon SN, Bhakat C, Sahani MS and Chirania BL. To develop suitable management practices for rearing camel. Annual Report. 1998; 15-21. NRCC, Bikaner, Rajasthan.

Woldearegay YH, Berhanu M and Mebratu AT. Study on management practices and production constraints of camel in Raya-Azebo district, Tigray, Northern Ethiopia. European Journal of Biological Sciences. 2015; 7(1):01-06.

Yohannes M, Zeleke M and Getachew G. Potentials of Camel Production in Babilie and KebribeyahWoredas of the Jijiga Zone, Somali Region, Ethiopia. Livestock Research for Rural Development 2007; 19(4).

FORM IV

(See Rule 8)

1.	Place of Publication	:	Camel Publishing House, 67, Gandhi Nagar (West), Near Lalgarh Palace, Bikaner-334001, Rajasthan
2.	Periodicity of its publication	:	Triannual
3.	Printer's Name	:	Tarun Kumar Gahlot
	(Whether citizen of India)	:	Yes
	Address	:	67, Gandhi Nagar (West), Near Lalgarh Palace, Bikaner-334001, Rajasthan
4.	Publisher's Name	:	Tarun Kumar Gahlot
	(Whether citizen of India)	:	Yes
	Address	:	67, Gandhi Nagar (West), Near Lalgarh Palace, Bikaner-334001, Rajasthan
5.	Editor's Name	:	Tarun Kumar Gahlot
	(Whether citizen of India)	:	Yes
	Address	:	67, Gandhi Nagar (West), Near Lalgarh Palace, Bikaner-334001, Rajasthan
6.	Names and address of individual who own the newspaper and partners or share holders holding more than one per cent of total capital.	:	Tarun Kumar Gahlot 67, Gandhi Nagar (West), Near Lalgarh Palace, Bikaner-334001, Rajasthan

I, hereby declare that the particulars given above are true to the best of my knowledge and belief.

Dated : 01.04.2024

Sd/-
Signature of Publisher

EVENTS ON INTERNATIONAL YEAR OF CAMELIDS (IYC-2024) BY ICAR-NRC ON CAMEL, BIKANER

Training & Workshop

Event-1: ICAR Sponsored a Short Course on 'Recent Developments in Livestock Phenome Data Recording Analysis and Interpretation in the Era of Genomics' from 03.01.2024 to 12.01.2024 (10 days). The training programme addresses phenomics data recording of camels and correlating with genomic information for rapid selection in the breeding programmes.

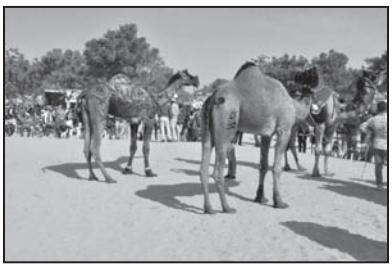
Event-2: Collaboration in **International Year of Camelids 2024 Workshop** at Lokhit Pashu-Palak Sansthan, Rajasthan, India on 10th January 2024. This programme was aimed to foster dialogue on the challenges and opportunities faced by camelid pastoralist communities

Event-3: Workshop on 'Arid Ecology and Camel: Conservation and Sustainability'organiszdat NRCC in collaboration with the Foundation for Ecological Security (NGO) on 13 January 2024. Issues of common natural resources for camel rearing, camel-pastoralism, sand dune stabilization, fodder resources of the arid system, community collectives for conservation of commons and arid ecology, etc. were discussed in detail.

Event-4: Workshop on 'Technology Management, Market Analysis and Commercialisation' was organised at ICAR-NRCC on 14.01.2024. Dr. Praveen Mallik (CEO, Agrinovate India Limited, New Delhi) was chief guest of the event. IPR issues in camel products, marketing and commercialisation of camel based products were discussed in detail with active participation of different stakeholders.

Event 5: Attended workshop on Camel Conservation in Rajasthan at Nagaur Livestock Fair on 16 to 17 February 2024. Lokhit Pashu-Palak Sansthan, Camel Charisma, NACROA (North American Camel Ranch Owners Association) participated in this event. The event was aimed to address the alarming decline in the camel population in Rajasthan, exacerbated by the enactment of the Rajasthan Camel (Prohibition of Slaughterand Regulation of Temporary Migration or Export) Law in 2015.

INTERNATIONAL CAMEL FESTIVAL- 2024 ON 13 JANUARY 2024



Camel race, dance competition decoration, hair cutting competition held at Camel Sports Complex, NRCC on the occasion of International Camel Festival- 2024 on 13 January 2024. Exhibition of products and technology from ICAR institutes, SAUs, NGOs, Private institutes was also organised.

DOI : 10.5958/2277-8934.2024.00010.9 *Vol 31 No 1, p 57-63*

MOLECULAR CHARACTERISATION OF KERATIN-ASSOCIATED PROTEIN-7 (*KRTAP7*) GENE FOR HAIR QUALITY IN INDIAN DROMEDARY CAMEL

Nistha Yadav[1], Urmila Pannu[1], Basanti Jyotsana[2], Ved Prakash[2], Sagar A. Khulape[2], Ajay Kumar[3], Gayatri Gujar[1] and Manju Nehara[1]

[1]College of Veterinary and Animal Science, RAJUVAS, Bikaner, Rajasthan – 334001, India
[2]ICAR-National Research Centre on Camel, Bikaner, Rajasthan – 334001, India
[3]Division of Textile Manufacture and Textile Chemistry, ICAR-CSWRI, Avikanagar, Malpura (Tehsil) Tonk, Rajasthan 304501

ABSTRACT

The keratin-associated proteins (*KRTAPs*) play important role in describing the physical and mechanical properties of the fibre *viz.* fibre thickness and curliness to the hair fibres. In this report, the molecular and functional characterisation of the *KRTAP7* gene in four Indian camel breeds i.e. Bikaneri, Jaisalmeri, Kachchhi and Mewari is described based on a comprehensive analysis of the nucleotide and amino acid sequences. The blood sample was collected from representative animals differing in fibre quality. The *KRTAP7* gene was amplified, sequenced and analysed for genetic characterisation. The coding sequence of the *KRTAP7* gene was of 264bp. The *KRTAP7* gene sequences from all four breeds of camel were identical. No SNPs were noticed in coding (CDS) and non-coding (5′ UTR and 3′ UTR) regions of *KRTAP7* gene. The complete coding sequence (CDS) of the *KRTAP7* gene translated to 87 amino acids (aa) long *KRTAP7* protein. The phylogeny analysis of nucleotide and protein sequence of Indian dromedary *KRTAP7* gene revealed closet relationship with *Camelidae* family. This study provides information about the *KRTAP7* gene in Indian dromedary camel.

Key words: Camel, dromedary, hair fibre, keratin-associated protein-7 (*KRTAP7*) phylogeny

Coat colour and fleece type traits have pleiotropic effect at genetic level and comes under qualitative traits as their expression is dependent on one or several genes with little or no environmental effects. On the other hand, the amount of fibre produced or fineness (diameter) have polygenic effect and come under quantitative traits as determined by several genes with minor effects per gene while major environment effect (Mackay, 2003).

Calderon *et al* (2021) identified set of SNPs located at or nearby candidate genes (*KRT, KRTAP, ASIP, MC1R, TYRP1*) for fibre quality and colour in *Huacaya alpacas* by genotyping by sequencing (GBS). Some keratin (*KRT*) and keratin-associated protein (*KRTAP*) genes are important candidate genes for fleece and fibre quality (Allain and Renieri, 2010). The process of keratinisation is most important among skin adaptations which helps in positive selection mechanism by interaction of fibrous (keratin) and matrix proteins (*KRTAPs*) (Alibardi *et al,* 2009; Rogers *et al,* 2007). Fibre is produced by secondary hair follicles which are composed of hair-keratins and keratin-associated proteins (*KAPs*). These multigene subfamilies encoded KAP proteins have specific in high or ultra-high sulphur (contributed by cysteine) content (HS) and a high glycine-tyrosine (HGT) (Wu *et al,* 2008). Such proteins also define the particular structural and chemical characteristics of the different types of hair, fur, wool and quills in various animals (Fujimoto *et al,* 2014). The discovery and analysis for variation in the quality of hair/fibre revealed over 100 and 88 keratin-associated proteins (*KRTAPs*) which have been identified in various mammalian species and human, respectively (Khan *et al,* 2014; Rogers *et al,* 2008). *KRTAPs* play an important role in describing the physical and mechanical properties of the fibre *viz.* fibre thickness and curliness to the hair fibres by acting as a matrix for cross linking the hair-keratins (Gong *et al,* 2016; Li *et al,* 2019). The different evolution rate is responsible for a high degree of diversification and homogenisation in *KRTAP7* gene family with more than 30 subfamilies. Our study considered molecular characterisation of the *KRTAP7* gene for hair quality traits in Indian dromedary camel.

SEND REPRINT REQUEST TO VED PRAKASH email: ved.prakash4@icar.gov.in

The pseudogenisation rate in one or more proteins from the repertoire of the KRTAP genes family are responsible for the diversification patterns in hair fibre in different species such as in sloth (175 KRTAP genes with 141 being intact for long and coarse hair) and dolphin (35 *KRTAPs*). The modification of hair structure and function due to changes in the KRTAP gene repertoire are responsible for surface adaptation in different species such as *alpaca* (fibre), *armadillo* (modified scales), hedgehog (spines) and dolphin (mostly hairless and aquatic). However, the reports on molecular characterisation of the *KRTAP7* gene with respect to the Indian camel is scanty. The present study was therefore, designed with the objective of characterising the *KRTAP7* gene and translated protein in Indian dromedary camel.

Materials and Methods

Sampling structure

The sampling was done under permission of Institutional Ethics Committee. The blood samples were collected from the jugular veins in BD Vacutainer® blood collection tubes from 35 camels of 4 breeds namely Bikaneri (10), Jaisalmeri (9), Kachchhi (6) and Mewari (10). The samples were collected from the institutional camel herd of ICAR-National Research Centre on Camel (NRCC) Bikaner, India. The animals were selected on the basis of hair quality attributes such as fibre diameter and medullation percent. The fibre diameter (µ) from sampled animals was ranging between 21.10-36.56 for Bikaneri, 24.44-73.61 for Jaisalmeri, 26.54-60.83 for Kachchhi and 36.98-62.19 for Mewari breed. The medullation per cent was ranging between 13.33-81.33 for Bikaneri, 32.33-97.00 for Jaisalmeri, 33.00-93.67 for Kachchhi and 39.00-94.00 for Mewari breed in sampled animals.

Molecular characterisation of the KRTAP7 gene

The total DNA was isolated from blood samples using the QIAamp DNA Blood Mini Kit (QIAGEN, Aarhus, Denmark) as per manufacturer's guidelines. The *KRTAP7* gene fragment was amplified from isolated genomic DNA samples using custom designed primers (Forward: **5'**AGGTATCACCCTATCCTGGTGT**3'**; Reverse: **5'**AGTCTGTGGGCTCCT TTGTATG**3'**) using reference genome sequence locus [NC_044511]. The PCR reaction mix (25 µL) for amplification of *KRTAP7* gene fragment was prepared by adding 1 µL of each primer (10 pmol), 2 µL of genomic DNA, 13 µL of Taq PCR Master Mix (Qiagen, USA) and 8 µL of Nuclease free water. The PCR reaction was performed in Veriti® thermocycler (Applied Biosystems, USA) using the time-temperature combination: an initial denaturation at 95° C for 5 min followed by 34 cycles of denaturation (94°C for 1 min), annealing (59.5°C for 45 sec) and extension (72 °C for 1 min) followed by a single cycle of final extension (72°C for 10 min). A single band of 995 bp was observed when the PCR products were checked for amplification by electrophoresis on 1.0% agarose gel (Himedia), in parallel with 100-1500bp NEX-GEN DNA ladder (Puregene, Genetix Biotech Asia Pvt. Ltd.) (Fig 1). The PCR products were purified using Wizard® SV Gel and PCR Clean-Up System kit (Promega Corporation, USA). The bidirectional sequencing of the purified *KRTAP7* amplicons were performed by Sanger's dideoxy chain termination method (Eurofin Genomics, USA). The forward and reverse sequences were manually curated and analysed using Codon Code Aligner Software (Codon Code Corporation, USA). The *KRTAP7* sequences generated for Indian dromedary camel breeds were compared with the reference genome sequence locus [NC_044511] using BLAST software program (http://www. ncbi.nlm.nih.gov/). The pair wise and multiple sequence alignments of identified Indian camel *KRTAP7* gene sequence were done to study the variation and identity with other reported camelid and the sequences of domesticated species using Clustal2.1(https://www.ebi.ac.uk/Tools/msa/clustalo/n) and dismat-EMBOSS (https://www. ebi.ac.uk/Tools/emboss/) software package. The estimation of evolutionary relationship and phylogenetic tree construction (Table 1) between nucleotide sequences and the deduced amino acid sequences of different species and Indian dromedary camel were inferred by Maximum Likelihood bootstrapped method using Molecular Evolutionary Genetics Analysis software (MEGA 11.0) (Tamura *et al*, 2021).

Results and Discussion

Molecular characterisation of KRTAP7 gene

The amplification and sequencing of *KRTAP7* gene was done in Indian dromedary camel breeds. The 995 base pairs long fragment of *KRTAP7* gene was amplified (Fig 1). The sequencing of the PCR products from 35 animals resulted in retrieval of 915 bp long sequence after alignment and editing of the forward and reverse sequences. The 915 bp long sequence covered 264 bp long coding region and 518 bp long non-coding 5′ UTR region and 133 bp long 3′ UTR region. The 264 bp long coding ORF domain

of *KRTAP7* gene translated into 87 amino acids (aa) length protein sequence in Indian dromedary camel breeds.

No SNPs were noticed in coding (CDS) and non-coding (5′ UTR and 3′ UTR) regions of *KRTAP7* gene. In resemblance to our study, no polymorphism in the CDS region of *KRTAP7* gene was observed in bovine species such as Chinese yak breeds and Indonesian zebu cattle (Arlud *et al,* 2017). However, in contrast to present study the identified novel SNPs at different positions of *KRTAP7*-1 were associated with the mechanical strength and shape of hair fibre in llama (c.99C>T, c.185G>A, c.198T>C and c.237C>G) (Daverio *et al,* 2019) and sheep (c.93C>A and c.173G>A) (Liu *et al,* 2014; Gong *et al,* 2012). The genetic variants with AA (n = 169) and AB (n = 51) genotypes were associated with wool production traits such as mean yield (79.9 ± 2.72% and 81.9 ± 3.37%) and mean staple length (MSL: 47.3 ± 0.57 mm and 50.9 ± 0.65 mm), respectively in Pakistani sheep breeds (Ullah *et al,* 2020). The hair characteristics are controlled by vast repertoire of keratin gene family such as 80 *KRTAPs* (25 families) in humans (Gong *et al,* 2012), 29 *KRTAPs* (13 families) in sheep (Li *et al,* 2017), 12 *KRTAPs* (9 families) in goats (Wang *et al,* 2017), 5 keratin (KRT) gene and 4 candidate gene as makers (BMP4, COL1A2, GLI1, SFRP4) in alpaca (Mendoza *et al,* 2020). Monomorphic nature of *KRTAP7* gene in yak and Indian dromedary camel indicates very limited variations, its unique intrinsic structural property (e.g., > 21% high glycine content) and vital functional role in strength and shape of hair fibre. Conclusively, the definite role of *KRTAP7* gene in wool traits *viz.* yield and structural variation was indicated in some mammalian species but not in Indian dromedary.

The CDS region and translated protein sequence for *KRTAP7* were subjected for comparative per cent identity analysis with different mammalian species (Table 2 and 3). The local alignment (NCBI-BLASTN and NCBI-BLASTP), identity matrix and distance matrix of targeted *KRTAP7* proteins indicated 100% identical sequence with the keratin associated protein7-1 gene of *Camelus dromedarius* (reference sequence). The lowest divergence for gene (72.47) and protein (4.60) was noticed with *Camelus bactrianus* and *Vicugna pacos,* respectively. However, *Camelus bactrianus* and *Camelus ferus* also showed 100% identity with each other among all compared sequences. Highest divergence for targeted protein was shown with *Sus scrofa* (79.90) and *Capra hircus* (47.06) while lowest identity was with *Mus musculus* (74.42). The, overall highest divergence for *KRTAP7* proteins (49.41) was noticed between *Mus musculus* and *Capra hircus* (Table 3).

Phylogenetic analysis

Phylogram revealed the dissemblance of *Sus scrofa, Capra hircus, Equus caballus, Mus musculus, Homo sapiens, Vicugna pacos, Bubalus bubalis* and from that of *Camelus dromedarius* during evolution. Phylogenetic relationship among considered nucleotide and amino acid sequences was established to infer the evolutionary history using the Maximum Parsimony method with 500 bootstrapped replicates (Fig 2 and 3). Multiple protein alignments for considered species was shown accordingly in Fig 4.

Table 1. Details of sequences subjected for comparison for *KRTAP7* gene.

S. No.	Species	Reference acc no.	Chr no.	Accession no. (Protein)	Gene (bp)	CDS (bp)	Protein (AA)
1	*Camelus dromedarius*	NC_044511.1	1	KAB1284088.1	732	264	87
2	*Camelus bactrianus*	NW_011514130.1	Un	XP_010954900.1	730	264	87
3	*Camelus ferus*	NC_045696.1	1	EQB78523.1	729	264	87
4	*Vicugna pacos*	NW_021964153.1	1	XP_006216075.1	734	264	87
5	*Homo sapiens*	NC_000021.9	21q22.11	NP_853637.2	721	264	87
6	*Mus musculus*	NC_000082.7	16; 16 C3.3	NP_082047.1	621	264	87
7	*Equus caballus*	NC_009169	26	XP_014591977.1	739	264	87
8	*Sus scrofa*	NC_010455.5	13	XP_003358967.2	597	258	85
9	*Bubalus bubalis*	NC_059157.1	1	XP_006053907.3	740	264	87
10	*Bos taurus*	KJ551549.1	1	AHZ89844.1	285	264	87
11	*Capra hircus*	NC_030808	1	QES86378.1	707	258	85
12	*Ovis aries*	NC_056054	1	QPP12018.1	676	258	85

acc. no.= Accession number; Chr no.= Chromosome number; Un= Unknown; bp=base pairs; CDS= Coding sequence; AA=Amino acids

Table 2. Per cent Identity Matrix of *KRTAP7* gene between Indian dromedary camel and different species subjected for comparison.

S.no.	Accession no.	1	2	3	4	5	6	7	8	9	10	11	12	13
1	Camelus		36.90	97.39	100.00	99.18	99.18	82.35	82.06	83.49	82.04	89.77	79.40	38.41
2	NC_000082.7	74.56		63.13	63.58	63.74	63.74	61.52	66.22	66.16	63.99	76.89	64.57	64.14
3	NW_021964153.1	76.70	76.49		97.26	96.84	96.98	80.70	78.17	80.55	78.88	89.39	77.12	76.28
4	NC_044511.1	76.50	76.01	76.09		99.18	99.18	80.34	78.87	81.32	78.98	89.77	77.41	76.43
5	NW_011514130.1	72.47	71.18	75.48	76.30		100.00	80.34	78.59	80.85	78.79	89.77	77.12	76.43
6	NC_045696.1	75.03	76.81	71.74	72.98	73.94		80.34	78.59	80.83	78.90	89.77	77.12	76.43
7	NC_010455.5	79.90	76.55	72.70	74.37	78.39	74.04		79.05	83.25	83.53	91.09	81.59	80.32
8	NC_000021.9	75.59	43.96	76.42	74.48	69.21	75.45	75.88		82.73	76.40	89.02	75.15	73.95
9	NC_009169.3	75.51	80.03	43.19	78.14	75.89	73.25	72.36	74.48		79.89	90.53	78.77	78.16
10	NC_059157.1	73.92	74.88	72.89	70.08	72.33	75.45	72.19	71.71	62.92		98.11	94.89	93.48
11	KJ551549.1	76.89	73.11	78.79	71.59	73.86	64.02	78.79	76.89	78.41	76.52		96.12	96.12
12	NC_030808.1	77.51	74.24	72.14	78.64	74.82	66.20	71.52	75.53	72.28	76.66	74.62		98.08
13	NC_056054.1	73.52	71.50	76.48	73.22	66.57	75.15	76.38	73.08	72.78	72.78	74.24	74.41	

Above diagonal: Per cent identity; below diagonal: Divergence

NC_000082.7: *Mus musculus;* NW_021964153.1: *Vicugna pacos;* NC_044511.1: *Camelus dromedarius*; NW_011514130.1: *Camelus bactrianus;* NC_045696.1: *Camelus ferus;* NC_010455.5: *Sus scrofa;* NC_000021.9: *Homo sapiens;* NC_009169.3: *Equus caballus;* NC_059157.1: *Bubalus bubalis;* KJ551549.1: *Bos taurus;* NC_030808.1: *Capra hircus;* NC_056054.1: *Ovis aries*.

Table 3. Per cent Identity Matrix of *KRTAP7* protein between Indian dromedary camel and different species subjected for comparison.

S.no.	Accession no.	1	2	3	4	5	6	7	8	9	10	11	12	13
1	NP_082047.1		77.38	76.74	78.57	80.23	79.07	78.57	80.23	72.09	74.42	74.42	75.58	75.58
2	XP_003358967.2	49.41		85.88	86.75	87.06	87.06	86.75	85.88	82.35	84.71	84.71	84.71	84.71
3	XP_014591977.1	27.59	41.18		89.41	89.66	89.66	89.41	89.66	87.36	89.66	89.66	89.66	89.66
4	QES86378.1	49.41	23.53	48.24		96.47	96.47	97.65	88.24	85.88	88.24	88.24	88.24	88.24
5	AHZ89844.1	25.29	38.82	10.34	43.53		97.70	96.47	88.51	86.21	88.51	88.51	88.51	88.51
6	XP_006053907.3	26.44	40.00	10.34	44.71	2.30		96.47	88.51	86.21	88.51	88.51	88.51	88.51
7	QPP12018.1	48.24	23.53	47.06	2.35	42.35	43.53		88.24	85.88	88.24	88.24	88.24	88.24
8	NP_853637.2	24.14	42.35	10.34	47.06	11.49	11.49	45.88		86.21	88.51	88.51	88.51	88.51
9	XP_006216075.1	32.18	42.35	12.64	48.24	13.79	13.79	47.06	13.79		95.40	95.40	93.10	93.10
10	Camelus	29.89	41.18	10.34	47.06	11.49	11.49	45.88	11.49	4.60		100.00	97.70	97.70
11	KAB1284088.1	29.89	41.18	10.34	47.06	11.49	11.49	45.88	11.49	4.60	0.00		97.70	97.70
12	XP_010954900.1	28.74	41.18	10.34	45.88	11.49	11.49	44.71	11.49	6.90	2.30	2.30		100.00
13	EQB78523.1	28.74	41.18	10.34	45.88	11.49	11.49	44.71	11.49	6.90	2.30	2.30	0.00	

Above diagonal: Percent identity; below diagonal: Divergence

NP_082047.1: *Mus musculus;* XP_003358967.2: *Sus scrofa;* XP_014591977.1: *Equus caballus;* QES86378.1: *Capra hircus;* AHZ89844.1: *Bos taurus;* XP_006053907.3: *Bubalus bubalis;* QPP12018.1: *Ovis aries;* NP_853637.2: *Homo sapiens;* XP_006216075.1: *Vicugna pacos;* KAB1284088.1: *Camelus dromedarius*; XP_010954900.1: *Camelus bactrianus;* EQB78523.1: *Camelus ferus.*

The phylogeny tree based on nucleotide and amino acid sequence for the KRTAP7 gene depicted different evolutionary patterns among species considered for evolutionary relationship analysis. Both the phylogeny trees depicted similar relationship patterns between Camelus ferus and Camelus dromedarius in comparison to other Camelidae species. The highest amino acid sequence homology was noticed among the Camelidae family followed by the Homo sapiens, Mus musculus, Sus scrofa, Equus caballus and other species. The nucleotide sequences of Capra hircus were farthest related compared to other bovine (cattle, buffalo) and ovine species. The multiple protein sequence analysis revealed the highest amino acid similarity between camelids and the highest amino acid differences with Mus musculus (Fig 4)

This maiden report describes the molecular characterisation of the *KRTAP7* gene and protein in four Indian dromedary camel breeds differing in

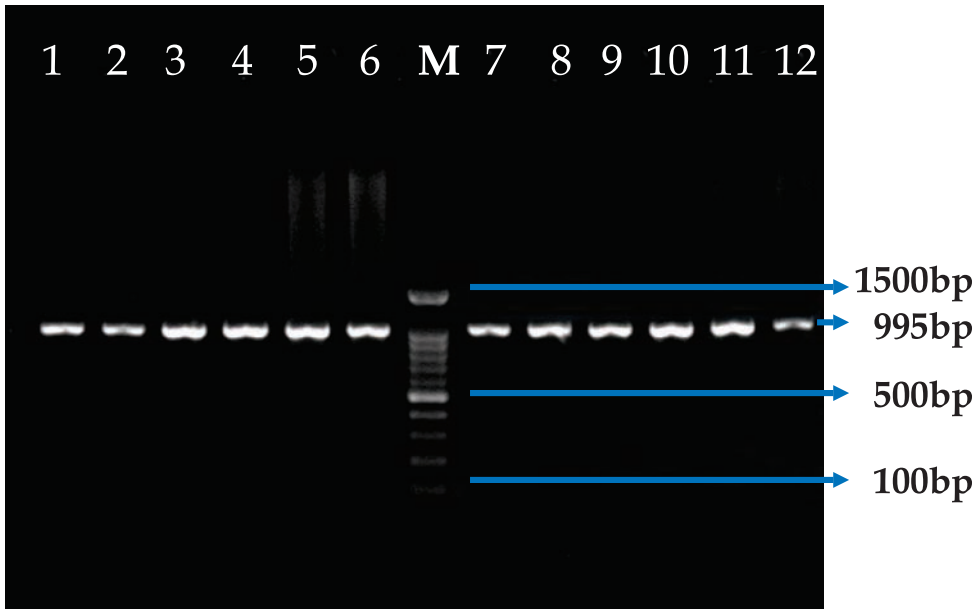
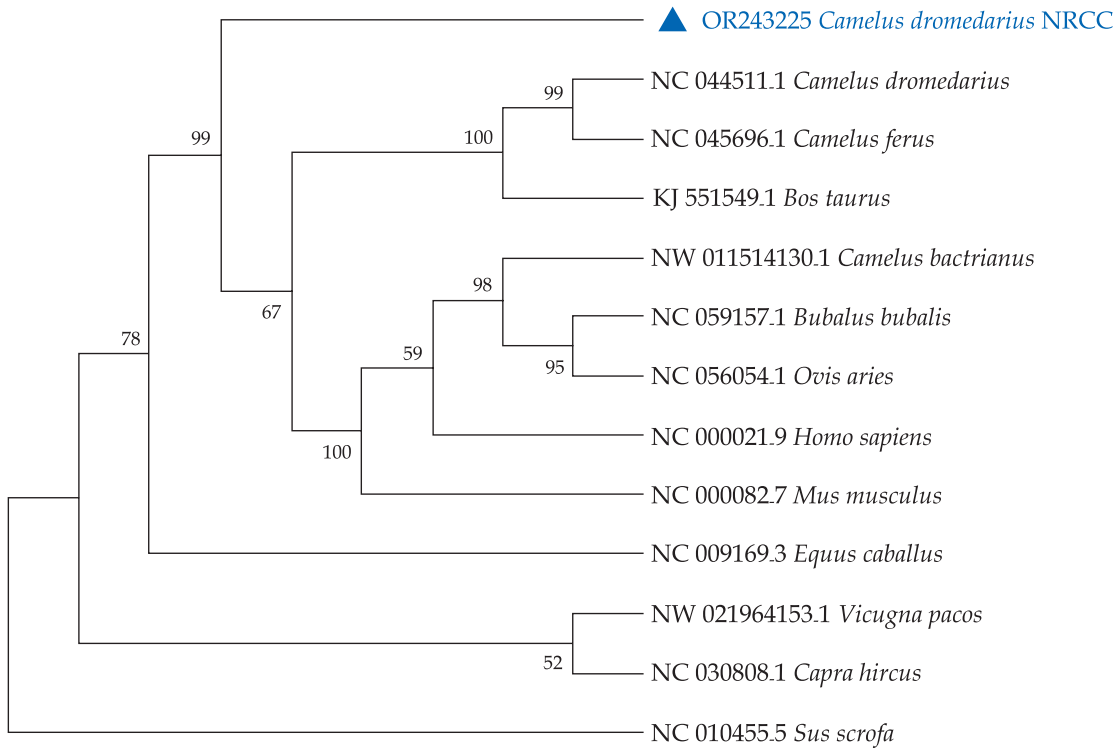


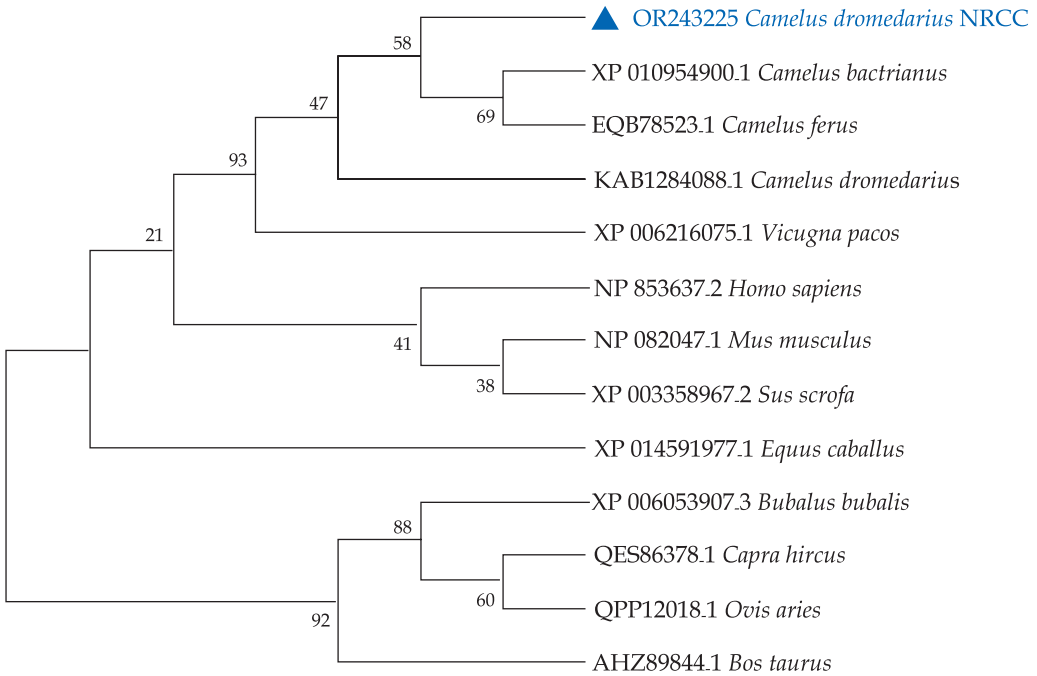
Fig 1. Agarose gel electrophoresis for amplification of the KRTAP7 gene in Indian camel breeds: - Lane 1-3: Mewari; Lane 4-6: Kachchhi; Lane M: 100-1500bp NEX-GEN DNA ladder; Lane 7-9: Bikaneri; Lane 10-12: Jaisalmeri



▲: Indicate considered sequences of India dromedary camel; N.B. in right represent the accession number and scientific name of representative mammalian species.

Fig 2. Phylogeny tree for Coding Sequences of the *KRTAP7* gene depicting evolutionary relationship between Indian camel and other mammalian species.

hair quality attributes. In our study, the identical consensus nucleotide sequence for the *KRTAP7* gene in four Indian camel breeds indicated the monomorphic nature of the gene. This monomorphic nature was present in high and low values of fibre diameter and medullation per cent. In addition,



▲: Indicate considered sequences of India dromedary camel; N.B. in right represent the accession number and scientific name of representative mammalian species.

Fig 3. Phylogenetic analysis for the KRTAP7 amino acid sequence depicting evolutionary relationship between Indian camel and other mammalian species.

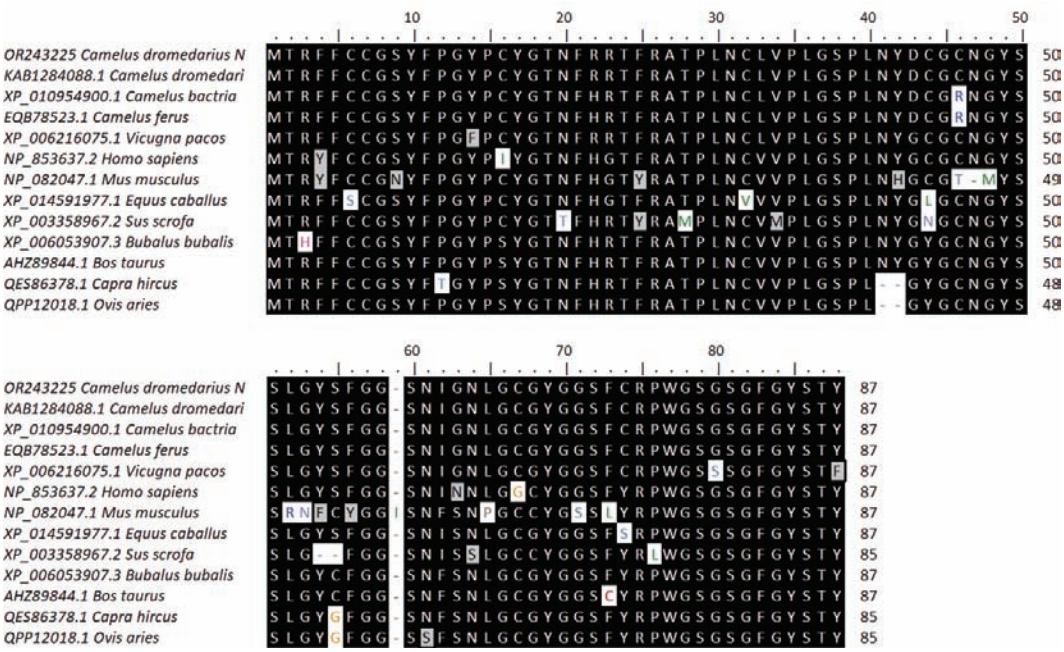


Fig 4. Multiple protein sequence alignment for *KRTAP7* protein with different species

considering other associated gene(s) may establish the genetic association of hair fibre traits.

Acknowledgements

The authors thank the Director, ICAR-NRCC, Bikaner for providing all the necessary support for the present study. The financial support for the first author by CVAS, Bikaner, Rajasthan, India with an Institutional fellowship during the work is thankfully acknowledged.

Conflict of Interest

No any conflict of interest.

References

Alibardi L, Dalla Valle L, Nardi A and Toni M. Evolution of hard proteins in the sauropsid integument in relation to the cornification of skin derivatives in amniotes. Journal of Anatomy. 2009; 214(4):560-586.

Allain D and Renieri C. Genetics of fibre production and fleece characteristics in small ruminants, Angora rabbit and south American camelids. Animal. 2010; 4(9):1472-1481.

Arlud S, He N, Sari EM, Ma ZJ, Zhang H, An TW and Han JL. Highly conserved keratin-associated protein 7-1 gene in Yak, Taurine and Zebu Cattle. Folia Biologica (00155500). 2017; 63(4).

Calderon M, More MJ, Gutierrez GA and Ponce de León FA. Development of a 76k Alpaca (*Vicugna pacos*) single nucleotide polymorphisms (SNPs) microarray. Genes. 2021; 12:291.

Daverio MS, Anello M, Ersinger VA, Alvarez S, Frank E, Vidal-Rioja L and Di Rocco F. Identification of llama *KRTAP7*-1 and KRTAP8-1 fibre genes and polymorphism screening. Small Ruminant Research. 2019; 175:149-154.

Fujimoto S, Takase T, Kadono N, Maekubo K and Hirai Y. KRTAP11-1, a hair keratin-associated protein, as a possible crucial element for the physical properties of hair shafts. Journal of Dermatological Science. 2014; 74(1):39-47.

Gong H, Zhou H, Forrest RH, Li S, Wang J, Dyer JM and Hickford JG. Wool keratin-associated protein genes in sheep-a review. Genes. 2016; 7(6):24.

Gong H, Zhou H, McKenzie GW, Yu Z, Clerens S, Dyer JM and Hickford JG. An updated nomenclature for keratin-associated proteins (KAPs). International Journal of Biological Sciences. 2012; 8(2):258.

Khan I, Maldonado E, Vasconcelos V, O'Brien SJ, Johnson WE and Antunes A. Mammalian keratin associated proteins (*KRTAPs*) subgenomes: disentangling hair diversity and adaptation to terrestrial and aquatic environments. BMC Genomics. 2014; 15(1):1-19.

Li S, Zhou H, Gong H, Zhao F, Wang J, Liu X and Hickford JG. Identification of the ovine keratin-associated protein 22-1 (KAP22-1) gene and its effect on wool traits. Genes. 2017; 8(1):27.

Li W, Gao F, Kan J, Deng J, Wang B and Hao S. Synthesis and fabrication of a keratin-conjugated insulin hydrogel for the enhancement of wound healing. Colloids and Surfaces B: Biointerfaces. 2019; 175:436-444.

Liu YX, Shi GQ, Wang HX, Wan PC, Tang H, Yang H and Guan F. Polymorphisms of KAP6, KAP7 and KAP8 genes in four Chinese sheep breeds. Genetics and Molecular Research. 2014; 13(2):3438-3445.

MacKay DJ. Information theory, inference and learning algorithms. Cambridge University Press. 2003.

Mendoza MN, Raudsepp T, More MJ, Gutiérrez GA and Ponce de León FA. Cytogenetic mapping of 35 new markers in the alpaca (*Vicugna pacos*). Genes. 2020; 11(5):522.

Rogers MA, Langbein L, Praetzel-Wunder S and Giehl K. Characterisation and expression analysis of the hair keratin associated protein KAP26. 1. British Journal of Dermatology. 2008; 159(3):725-729.

Rogers MA, Winter H, Langbein L, Wollschläger A, Praetzel-Wunder S, Jave-Suarez LF and Schweizer J. Characterisation of human KAP24. 1, a cuticular hair keratin-associated protein with unusual amino-acid composition and repeat structure. Journal of Investigative Dermatology. 2007; 127(5):1197-1204.

Tamura K, Stecher G and Kumar S. MEGA11: molecular evolutionary genetics analysis version 11. Molecular Biology and Evolution. 2021; 38(7):3022-3027.

Ullah F, Jamal SM, Zhou H and Hickford JG. Variation in the KRTAP6-3 gene and its association with wool characteristics in Pakistani sheep breeds and breed-crosses. Tropical Animal Health and Production. 2020; 52:3035-3043.

Wang J, Che L, Hickford JG, Zhou H, Hao Z, Luo Y and Li S. Identification of the caprine keratin-associated protein 20-2 (KAP20-2) gene and its effect on cashmere traits. Genes. 2017; 8(11):328.

Wu DD, Irwin DM and Zhang YP. Molecular evolution of the keratin associated protein gene family in mammals, role in the evolution of mammalian hair. BMC Evolutionary Biology. 2008; 8(1):1-15.

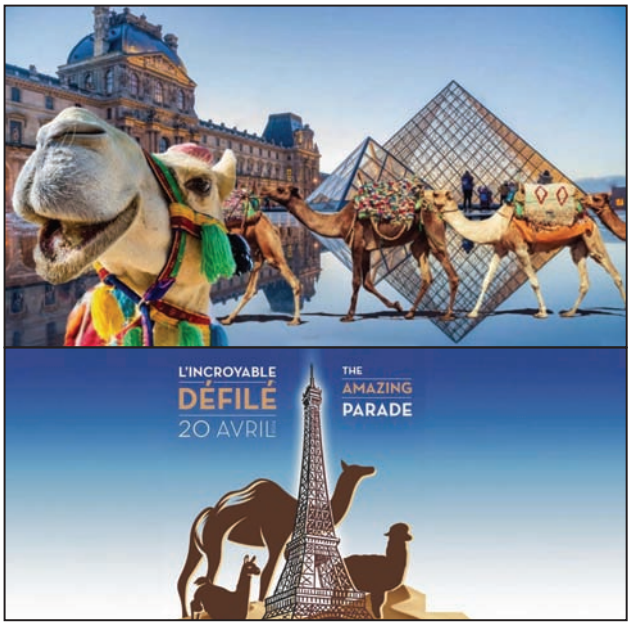
JCPR BAGS THE GOURMAND AWARD

Edouard Cointreau, President, Gourmand Awards informed that the Journal of Camel Practice and Research has been selected for the prestigious category B27 of the 30th Gourmand Awards in the International Year of camelids 2024 (date and venue will be declared soon). My congratulations to all the members of editorial board and authors.

B27 UNITED NATIONS YEAR OF CAMELIDS 2024

- FAO - Camelids Handbook and Toolkit 2024 (FAO) 24 pages
- France - www.camelids.cirad.fr
- India - Journal of camel practice and research (Camel Publishing House)
- UAE - www.camenet.ae
- USA - Alpacas magazine (Alpacas Owners Association)

A PARADE OF CAMELS, DROMEDARIES AND LLAMAS IN PARIS



A major camelid parade is announced in Paris on Saturday April 20, 2024 with the participation of 32 foreign delegations! There will be participation and presence of 32 foreign delegations, including the United States, Canada, England, Pakistan, Egypt, India, Mauritania, Senegal, Tanzania, Tunisia, Qatar, Spain, Algeria, Niger, Chad, Morocco and even Australia. During this parade, each of these delegations will be preceded by a camel, a llama or an alpaca, while folk groups accompany. This megaevent will be part of celebration for "International Year of the Camelids 2024".

The F.F.D.C.F.E. (French Federation for the Development of Camelidae in France and Europe) and Christian Schoettl, the Mayor of the small town of Janvry in Essonne are behind this great event. The mayor confirms having obtained authorisation from the Police Prefecture for this event, announced as a "festival of nomadic cultures" and supported by FAO (Food and Agriculture Organisation), UNESCO and the ICO (International Camelids Organisation). The camels will not be ridden during this stroll. The World Year of the Camelids and the parade of camels and dromedaries on April 20 was officially launched on February 26 at 12 p.m. during the Agricultural Show at Paris Expo – Porte de Versailles.

DOI : 10.5958/2277-8934.2024.00011.0 Vol 31 No 1, p 65-69

ISOLATION AND ANTIMICROBIAL RESISTANCE PROFILE OF *Escherichia coli* IN RAW CAMEL MILK AND CAMEL MILK POWDER

Amita[1], Deepika Dhuria[1], Manohar Sain[2], Yogesh Kumar[3], Vaishali[2] and Devendra Choudhary[2]

[1]Department of Veterinary Public Health & Epidemiology, RAJUVAS, Bikaner, Rajasthan-334001, India
[2]Animal Bio-Medical Waste Disposal Technology Centre, RAJUVAS, Bikaner, Rajasthan-334001, India
[3]National Research Centre on Camels, Bikaner, Rajasthan-334001, India

ABSTRACT

The present study was conducted to isolate *Escherichia coli* from raw camel milk and camel milk powder samples and identify antimicrobial pattern. A total of 200 samples consisting of raw camel milk (n=100) and camel milk powder (n=100) were collected from National Research Centre on Camels, Bikaner (Rajasthan). Several biochemical tests (imvic, lactose, glucose, sorbitol, sucrose, etc.) were performed to confirm *E. coli* isolates using Hi*E. coli*TM kits. Antibiotic resistance patterns in the *Escherichia coli* isolates were determined by the Kirby-Bauer disk diffusion method against 12 antibiotics. Twenty eight isolates of *Escherichia coli* were found in the raw camel milk samples and 5 isolates of *Escherichia coli* were present in camel milk powder samples. The *Escherichia coli* isolates were highly resistant to penicillin-G (100%) followed by chloramphenicol (87.87%), amoxicillin (81.81%) and erythromycin (63.63%). This was possibly due to poor personal hygiene of the milker, camel health, environment, poor equipment sanitation, storage and transport conditions. The existence of multi-drug resistance points to take strict measures to diminish its prevalence and combat antimicrobial resistance in food animals.

Key words: Antimicrobial resistance, camel milk powder, *Escherichia coli*, raw camel milk

Numerous microorganisms can contaminate milk and its by-products and contaminated raw milk and dairy products are the major sources of food-borne illnesses (Javaid *et al,* 2009, Zuleka *et al,* 2016). *Escherichia coli* stands out as one of the primary contaminants found in raw milk and it's presence consistently indicates faecal contamination and the potential existence of other enteric pathogens in raw milk, posing a significant public health risk to consumers (Soomro *et al,* 2002). The foodborne pathogens (including *Listeria monocytogenes,* enteropathogenic *E. coli*, *Staphylococcus aureus,* and *Salmonella* spp.) account for 65 and 72% of cases of foodborne illnesses and foodborne deaths, respectively (WHO, 2015). Milk and milk products are considered to be among the primary sources for these pathogens (Oliver *et al,* 2005). The growth behaviour of foodborne pathogens, i.e. *Staphylococcus aureus, Listeria monocytogenes*, *E. coli* O157:H7 and Salmonella spp. was studied in pasteurised camel milk and compared with pasteurised bovine milk at different incubation temperatures (Abusheliabi and Ayyash, 2017). Abera *et al* (2016) demonstrated bacterial contamination (88.7%) in raw camel milk samples. The overall mean Total Bacterial Counts and Coliform Counts of contaminated raw camel milk samples were 4.75 ± 0.17 and 4.03 ± 0.26 log CFU/ml, respectively. *E. coli* (31.5 %) was among the major bacterial microorganisms isolated. However, certain strains of *E. coli* pose risks to humans and are present in food animals. Among these strains, *E. coli* O157:H7 is the most widely recognised pathogenic variant (Oliver *et al,* 2009). In arid and semiarid regions, camel milk stands out as a crucial food source for pastoral communities. Recently, urban populations residing in resource-rich areas have shown a growing interest in consuming camel milk (Farah and Fischer, 2004).

The consumption of milk contaminated with antibiotics poses public health hazards, including allergic reactions, alterations in intestinal microflora and the proliferation of antibiotic-resistant pathogenic bacteria (Sheikh *et al,* 2013). The frequency of antibiotic-resistant bacteria could serve as a gauge for the extent of antimicrobial usage in livestock (Yang *et al,* 2015). Antimicrobial resistance is associated with the overutilisation of antimicrobial medications in food production, among animals and humans.

SEND REPRINT REQUEST TO AMITA email: amita171298@gmail.com

Research indicates that the prevalence of multi-drug resistance in *E. coli* is a significant global issue. Nonetheless, there has been limited exploration of this phenomenon, especially in developing nations (Rahimi and Nayebpour, 2012).

Materials and Methods

Sample collection

A total of 200 samples consisting of raw camel milk (n=100) and camel milk powder (n=100) were collected aseptically in sterile glass bottles and milk powder in sterile plastic bags from National Research Centre on Camels, Bikaner (Rajasthan). These were taken to the laboratory and stored at 4°C.

Isolation and identification of E. coli

10 ml of sample was added to 90 ml MacConkey broth for raw camel milk and 10 gm of camel milk powder samples was added to 90 ml MacConkey broth and homogenised. The homogenate was incubated overnight at 37°C for enrichment of *E. coli*. The broth was streaked on a MacConkey agar (MCA) plate and incubated at 37°C for 24 hrs to obtain isolated colonies of bacteria. After 24-hour period of incubation, the individual isolated colonies were placed onto Eosin Methylene Blue agar (EMB) plates to isolate *Escherichia coli*. These were then further incubated for 24 hours at 37°C. Colonies showing dark centre with metallic sheen were considered as *E. coli*. All the *E. coli* isolates were further confirmed by gram staining, biochemical tests and preserved for additional bacterial identification.

Biochemical Characteristics

The isolates were subjected to a series of different biochemical tests using the HiEcoliTM Identification Kit (HiMedia, Mumbai) for *E. coli* confirmation.

Antibiotic susceptibility pattern of E. coli

The antimicrobial susceptibility testing for all *E. coli* isolates was performed using the Kirby-Bauer disk diffusion method against 12 antibiotics. These antibiotics included chloramphenicol, oxacillin, penicillin-G, erythromycin, azithromycin, tetracycline, streptomycin, gentamicin, ampicillin, ciprofloxacin, ceftriaxone and amoxicillin. For susceptibility testing, a pure culture of all identified *E. coli* cultures was taken from nutrient broth and a cotton swab was used to streak the bacteria around the surface of Muller-Hinton agar and wait for 3-5 minutes for the solution to dry. Antibiotic disks were then placed on the agar surface using clean sterile forceps and gently pressed to confirm their attachment. Following this, the plates were aerobically incubated at 37°C for 24 hrs. Finally, the diameters of the zone of inhibition around the discs were measured to the nearest millimetre using the meter scale and the isolates were classified as susceptible, intermediate and resistant to the drugs tested according to the chart provided by the manufacturer.

Results

Microbiological isolation and identification of E. coli

The findings of the current investigation showed that among the 200 samples analysed, 33 samples tested positive for *E. coli*. The isolates were identified as having a pinkish-red colour colony on MacConkey agar plates (Fig 1) and revealed a greenish metallic sheen on Eosin methylene blue agar plates (Fig 2). The Gram staining of the isolates revealed small rod- shaped organisms with a pink colour arranged singly or in pairs or short chains.

Biochemical characterisation of E. coli

The isolates that demonstrated positive results for the methyl red, indole, glucuronidase, nitrate reduction, ONPG, lysine utilisation, lactose, glucose, sucrose and sorbitol sugar tests, but tested negative for the Voges-Proskauer and citrate utilisation tests, were confirmed as *E. coli* (Fig 3).

Table 1. Biochemical characterisation of *E. coli*.

S. No.	Test	Reaction
1.	Methyl red	Positive
2.	Voges Proskauer's	Negative
3.	Citrate Utilisation	Negative
4.	Indole	Positive
5.	Glucuronidase	Positive
6.	Nitrate Reduction	Positive
7.	ONPG	Positive
8.	Lysine Utilisation	Positive
9.	Lactose	Positive
10.	Glucose	Positive
11.	Sucrose	Positive
12.	Sorbitol	Positive

Antimicrobial Resistance Pattern of E. coli

In the present investigation, a total of 12 distinct antibiotics were employed to assess the pattern of antibiotic resistance for 28 isolates of *Escherichia coli* isolated from raw camel milk, alongwith 5 isolates

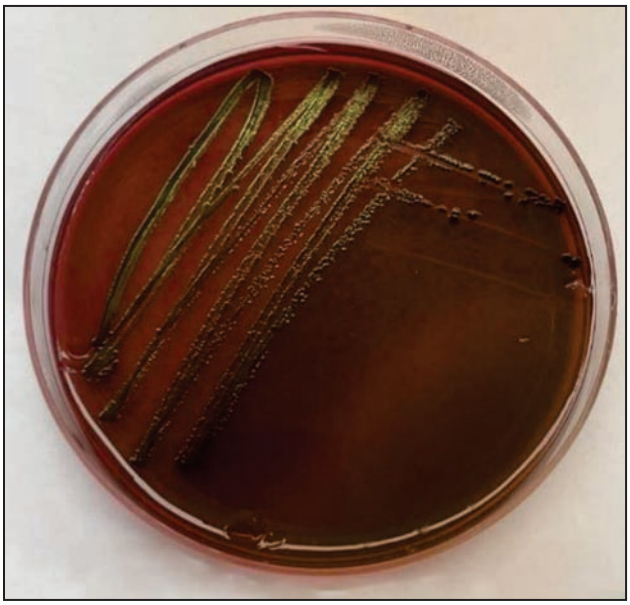


Fig 1. Isolation of *E. coli* on EMB Agar.

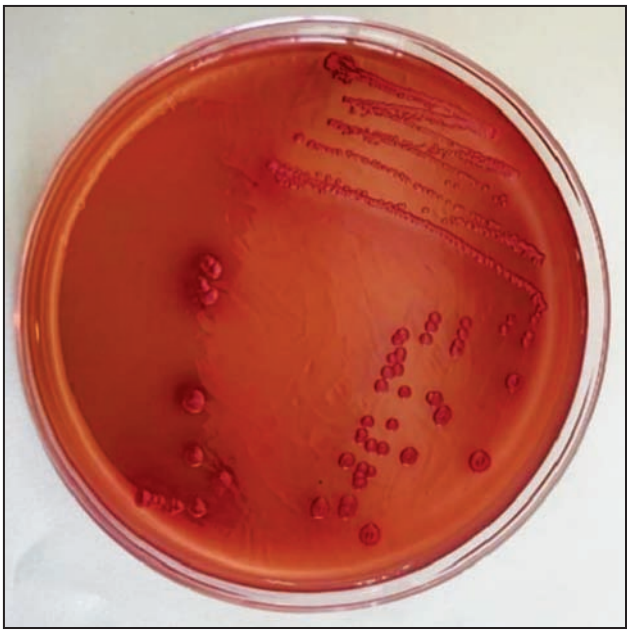


Fig 2. Isolation of *E. coli* on MacConkey Agar.

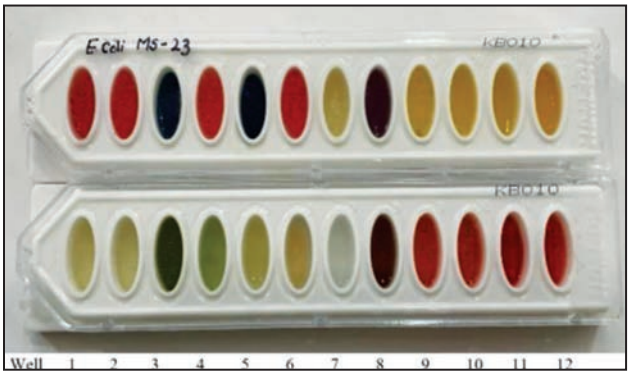


Fig 3. Biochemical test for *E. coli* isolates

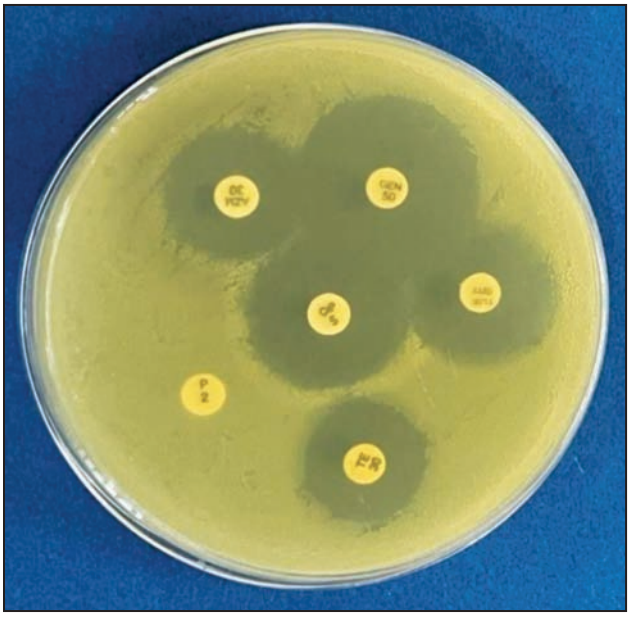


Fig 4. Antibiotic susceptibility pattern of *E. coli*.

of *Escherichia coli* retrieved from camel milk powder. Reactions of *E. coli* to antibiotics were classified into sensitive, intermediate and resistant categories. Each of the isolates demonstrated diverse levels of resistance and sensitivity to the antibiotics employed in this study. The antibiotic susceptibility pattern for *E. coli* isolated from raw camel milk and camel milk powder samples showed the highest resistance to penicillin-G (100 %) followed by chloramphenicol (87.87%), amoxicillin (81.81%) and erythromycin (63.63%).

The antibiotic susceptibility pattern for all the *E. coli* isolates in raw camel milk and camel milk powder samples for different antibiotic has been shown in Table 2.

Discussion

Out of 200 samples, 33 isolates (16.5%) were found positive for *E. coli* which exhibited distinctive features such as bright pinkish-red colonies on MacConkey agar, greenish metallic sheen colonies on EMB agar and pinkish-red coloured, small rod-shaped Gram-negative bacilli in Gram's staining. Isolates that demonstrated positive results for the methyl red, indole, glucuronidase, nitrate reduction, ONPG, lysine utilisation, lactose, glucose, sucrose and sorbitol sugar tests, but test negative for the Voges-Proskauer and citrate utilisation tests, were confirmed as *E. coli*. The disparities observed across various studies could stem from variations in sample size, sanitation practices related to milking equipment, diverse milking methods, geographical factors, environmental conditions, intervals of

Table 2. Results of antibiotic resistance profile of *Escherichia coli* isolates.

S. No.	Name of Antibiotics	Resistance	Intermediate	Sensitive
1.	Amoxicillin	27 (81.81%)	0 (0%)	6 (18.18%)
2.	Ampicillin	30 (90.90%)	0 (0%)	3 (9.09%)
3.	Azithromycin	0 (0%)	9 (27.27%)	24 (72.72%)
4.	Ceftriaxone	20 (60.60%)	1(3.03%)	12 (36.36%)
5.	Chloramphenicol	29 (87.87%)	0 (0%)	4 (12.12%)
6.	Ciprofloxacin	0 (0%)	0 (0%)	33 (100%)
7.	Erythromycin	21 (63.63%)	5 (15.15%)	7 (21.21%)
8.	Gentamicin	14 (42.42%)	0 (0%)	19 (57.57%)
9.	Oxacillin	19 (57.57%)	6 (18.18%)	8 (24.24%)
10.	Penicillin-G	33 (100%)	0 (0%)	0 (0%)
11.	Streptomycin	5 (15.15%)	8 (24.24%)	20 (60.60%)
12.	Tetracycline	18 (54.54%)	12 (36.36%)	3 (9.09%)

milk transportation and overall hygiene standards (Soomro *et al,* 2002). Furthermore, the presence of *E. coli* in milk does not invariably denote direct faecal contamination; rather, it implies insufficient hygiene practices and unsanitary procedures during milking and subsequent milk handling. Such circumstances pose a potential public health hazard to consumers (Meshref, 2013). Milk can possibly be contaminated from various sources, such as infected udders, milk handlers with inadequate personal hygiene, low-quality water and improperly cleaned or sanitised containers (Saeed *et al,* 2022). All of these factors contribute to the contamination of milk (Chye *et al,* 2004). In present study, the susceptibility of the *E. coli* isolates against twelve commonly used antimicrobials was tested and the isolates were characterised as susceptible, intermediate and resistant based on the size of the zone of inhibition. According to the test results most of the *E. coli* isolates were resistant to penicillin-G (100%), chloramphenicol (87.87%), amoxicillin (81.81%) and erythromycin (63.63%). (Table 3). Similar studies conducted by Mohammadi *et al* (2013) and Gezahegn *et al* (2023) observed comparable outcomes, indicating a 100% sensitivity to ciprofloxacin, mirroring the findings of the current study. Similarly, Alam *et al* (2017) demonstrated a 100% resistance to penicillin G, aligning closely with the results of the present investigation. Islam *et al* (2016) reported an 86.67% resistance to amoxicillin, a result closely resembling that of the present study. Dehkordi *et al* (2014) showed 84% resistance to tetracycline and also observed 36% resistance to streptomycin which is higher than the present investigations. Adzitey *et al* (2018) indicated a 61.8% resistance to erythromycin, which bears close relevance to the current study. The growth of antibiotic resistance among bacteria such as *E. coli* poses an important public health concern.

Conclusion

The frequency of contamination of *E. coli* was significantly higher in raw camel milk samples than in the camel milk powder samples. Elevated levels of *Escherichia coli* contamination were observed in raw milk samples, primarily due to inadequate hygiene practices. The *Escherichia coli* isolates were highly resistant to penicillin-G (100%) followed by chloramphenicol (87.87%), amoxicillin (81.81%) and erythromycin (63.63%). Additionally, the indiscriminate use of antimicrobial drugs in both humans and animals must be avoided to protect the public from ingesting antimicrobial resistant pathogens.

Conflicts of Interest

The authors declare no conflict of interest.

References

Abera T, Legesse Y, Mummed B. et al. Bacteriological quality of raw camel milk along the market value chain in Fafen zone, Ethiopian Somali regional state. 2016; BMC Res Notes 9, 285. https://doi.org/10.1186/s13104-016-2088-1

Abusheliabi Aisha and Ayyash Mutamed. Growth inhibition of foodborne pathogens in camel milk: *Staphylococcus aureus, Listeria monocytogenes, Salmonella* spp. and *E. coli* O157:H7. Czech Journal of Food Sciences; Prague. 2017; 35(4):311-320. DOI:10.17221/84/2017-CJFS

Adzitey F, Amposah, CA and Teye GA. Prevalence and antimicrobial resistance patterns of *Escherichia coli* isolates from cow milk, milk products and handlers in the tamale metropolis of Ghana. Nigerian Veterinary Journal. 2018; 39(4):338-345.

Alam MKU, Akther S, Sarwar N, Morshed S and Debnath GK. Prevalence and antimicrobial susceptibility of

Escherichia coli O157 isolated from raw milk marketed in Chittagong, Bangladesh. Turkish Journal of Agriculture Food Science and Technology. 2017; 5(3):214-220.

Chye FY, Abdullah A and Ayob MK. Bacteriological quality and safety of raw milk in Malaysia. Food Microbiology. 2004; 21(5):535-541.

Dehkordi FS, Yazdani F, Mozafari J and Valizadeh Y. Virulence factors, serogroups and antimicrobial resistance properties of *Escherichia coli* strains in fermented dairy products. BMC Research Notes. 2014; 7(1-8):217.

Farah Z and Fischer A. An introduction to the camel. Milk and Meat from the Camel Handbook on Products and Processing. 2004; 10(6):15-22.

Gezahegn E, Guyassa C, Beyene T, Olani A and Isa M. Isolation, identification and antimicrobial susceptibility pattern of *Salmonella*, *Escherichia coli* and *S. aureus* from selected dairy farms in Bedele and Nekemte Districts, Western Ethiopia. International Journal Veterinary Science Research. 2023; 9(4):080-090.

Islam MA, Kabir SML and Seel SK. Molecular detection and characterisation of *Escherichia coli* isolated from raw milk sold in different markets of Bangladesh. Bangladesh Journal of Veterinary Medicine. 2016; 14(2): 271-275.

Javaid SB, Gadahi JA, Khaskeli M, Bhutto MB, Kumbher S and Panhwar AH. Physical and chemical quality of market milk sold at Tandojam, Pakistan. Pakistan Veterinary Journal, 2009; 29(1):27-31.

Meshref AMS. Bacteriological quality and safety of raw cow's milk and fresh cream. Slovenian Veterinary Research. 2013; 50(1):21-30.

Mohammadi P, Abiri R, Rezaei M and Salman zadeh-Ahrabi S. Isolation of Shiga toxin- producing Escherichia coli from raw milk in Kermanshah, Iran. Iranian Journal of Microbiology. 2013; 5(3):233.

Oliver SP, Jayarao BM and Almeida RA. Foodborne pathogens in milk and the dairy farm environment: Food safety and public health implications. Foodborne Pathogens and Disease. 2005; 2:115-129.

Oliver SP, Boor KJ, Murphy SC and Murinda SE. Food safety hazards associated with consumption of raw milk. Foodborne Pathogens and Disease. 2009; 6(7):793-806.

Rahimi E and Nayebpour F. Antimicrobial resistance of *Escherichia coli* O 157: H7/NM isolated from faeces of ruminant animals in Iran. Journal of Cell Animal Biology. 2012; 6(6):104-108.

Saeed E, Amer AAEM, Keshta HG, Hafez EE, Sultan RM and Khalifa E. Prevalence, antibiotic sensitivity profile and phylogenetic analysis of *Escherichia coli* isolated from raw dromedary camel milk in Matrouh Governorate, Egypt. Journal of Advanced Veterinary and Animal Research. 2022; 9(1):138.

Sheikh JA, Rashid M, Rehman MU and Bhat MA. Occurrence of multidrug resistance shiga-toxin producing *Escherichia coli* from milk and milk products. Veterinary World. 2013; 6(11):915.

Soomro AH, Arain MA, Khaskheli M and Bhutto B. Isolation of *Escherichia coli* from raw milk and milk products in relation to public health sold under market conditions at Tandojam. Pakistan Journal of Nutrition. 2002; 1(3):151-152.

WHO. Who Estimates of the Global Burden of Foodborne Diseases: Foodborne Disease Burden Epidemiology Reference Group 2007–2015. Geneva, World Health Organization. 2015.

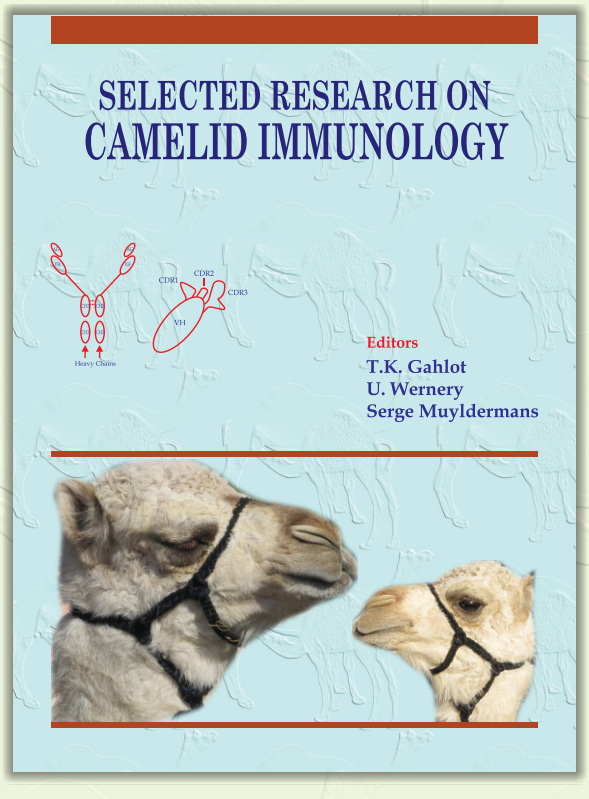
Yang FL, Shen C, He BX, Yang YY, Gong DC and Li XS. The prevalence of heifer mastitis and its associated risk factors in Huanggang, Central China. Tropical Animal Health and Production. 2015; 47(1):87-92.

Zuleka IM, Abebe MS, Awot TM, Belayneh GA, Tehetna AT. and Kumar N. Prevalence and antimicrobial resistance of *Escherichia coli* isolated from camel milk in Somali region, Ethiopia. Indian Journal of Animal Health. 2016; 55(2):119-128.

SELECTED RESEARCH ON CAMELID IMMUNOLOGY

(Hard Bound, 392 pages, few figs coloured, Edition 2016)

In 1989 a group of biologists led by Raymond Hamers at the Free University Brussels investigated the immune system of dromedaries. This discovery was published in Nature in 1993. Based on their structure, these peculiar camelid antibodies have been named Heavy Chain Antibodies (HCAb), as they are composed of heavy chains only and are devoid of light chains. Sera of camelids contain both conventional heterotetrameric antibodies and unique functional heavy (H)-chain antibodies (HCAbs). The smaller size and monomeric single domain nature make these antibodies easier to transform into bacterial cells for bulk production, making them ideal for research purposes. Camelid scientists world over were greatly fascinated by a new field of research called "Camelid Immunology". Significant research has been done on camelid immunology in recent decade. In order to benefit future camelid immunology researchers, this book was planned in the series of "Selected Topics" by Camel Publishing House with a title- "Selected Research on Camelid Immunology" edited by T.K. Gahlot, U. Wernery and Serge Muyldermans. This book is a unique compilation of research papers based on "Camelid Immunology" and published in Journal of Camel Practice and Research between 1994-2015. Research on this subject was done in 93 laboratories or institutions of 30 countries involving about 248 scientists. In terms of number of published papers in JCPR on the immunology the following countries remain in order of merit (in parenthesis), i.e. Iran (1), India and UAE (2), China and Saudi Arabia (3), Sudan (4), Kenya and Belgium (5), USA (6), Germany (7) and so on. The book contains 11 sections and is spread in 384 pages. The diverse sections are named as overview of camel immune system; determinates of innate immunity, cells, organs and tissues of immune system; antibodies; immunomodulation; histocompatibility; seroprevalence, diagnosis and immunity against bacteria, viruses, parasites and combination of other infections; application of camel immunoglobulins and applications of immune mechanisms in physiological processes. The camelid immunology has to go a long way in its future research, therefore, this reference book may prove quite useful for those interested in this subject. Book can be seen on www.camelsandcamelids.com.



Editor:
T.K. Gahlot
U. Wernery
Serge Muyldermans

Edition: 2016

Publisher:
Camel Publishing House
67, Gandhi Nagar West, Near Lalgarh Palace,
Bikaner-334001 Rajasthan, India
email: tkcamelvet@yahoo.com

Website:
www.camelsandcamelids.com
www.tkgahlotcamelvet.com

Price: US $ 475
INR 12500

ISBN 81-903140-4-1

DOI : 10.5958/2277-8934.2024.00012.2 *Vol 31 No 1, p 71-75*

SURGICAL REPAIR OF BILATERAL MANDIBULAR FRACTURE USING EXTERNAL SKELETAL FIXATION (ESF) TECHNIQUE IN SIX DROMEDARY CAMELS (*Camelus dromedarius*)

H.S. Bhabhor, Mahendra Tanwar, P. Bishnoi, Sakar Palecha, A.K. Bishnoi, K. Kachwaha and Narendra Singh

Department of Veterinary Surgery and Radiology, College of Veterinary and Animal Science, Rajasthan University of Veterinary and Animal Sciences, Bikaner, Rajasthan, India

ABSTRACT

Six camels (3 male and 3 female) with age group of 7 to 13 year were presented with mandibular fracture. In all the animals bilateral mandibular fractures were confirmed by clinical and radiographical examination. Fracture was surgically managed by external skeletal fixation (ESF) under general anaesthesia using Xylazine HCL @ 0.4 mg/kg BW along with Ketamine @ 2 mg/kg BW, intravenously. End threaded negative profile pins (3 mm) were used at the rostral and caudal side (bilateral) of fracture fragments. The average period of fracture healing was 10.83±1.11 weeks on follow-up period. This technique was found safe and achieved the rigid fixation at the fracture site in both the transverse and oblique type of mandibular fracture effectively.

Key words: Camel, external skeletal fixation, fracture, mandible

The mandible or lower jaw is predisposed to the fracture of horizontal ramus of mandible due to presence of alveoli of tushes and mental canal in the long interdental space. Mandibular fractures occur commonly during rut season or breeding season (Gahlot, 2005; Ahmed, 2011; Siddiqui *et al,* 2012; Parashar and Gahlot, 2023; Rastabi *et al,* 2017; Al-Sobayil *et al,* 2020; Awwad *et al,* 2022). During this season the camel under rut become active, vicious and tend to bite each other leading to abnormal stress forces on the weaker portions of horizontal ramus of mandible leading to fracture (Gahlot, 2000; Bhabhor and Tanwar, 2023). Fracture of mandible leads to hanging down of lower jaw, thus making both the lips apart and hence impairs prehensions. Other symptoms include drooling of saliva, local swelling and tongue protrusion (Fubini and Ducharme, 2017; Niwas *et al,* 2020). Mandibular fractures in camel, are different from other animals, so the successful repair of this fracture depends mainly on the use of suitable methods of immobilisation (Al-Sobayil *et al,* 2020). Therefore, selection of a procedure should be dependent upon the bone involved, severity of the fracture, availability of anaesthesia, equipment, instrumentation, skill and experience of the surgeon (Ahmed and Al-Sobayil, 2012). External fixation techniques have been attempted previously to repair the mandibular fractures in camels with varying success (Gahlot *et al,* 1989; Parashar and Gahlot, 2023; Zamos *et al,* 1992). Present investigation was done to evaluate the management of mandibular fractures in camels using external skeletal fixation technique.

Materials and Methods

The clinical study was done under permission from the Institutional Ethics Advisory Committee with IAEC approval no i.e. CVAS/IAEC/CPCSEA-2044/GO/Re/SL/18/2019/12. The camels with mandibular fractures were brought to Veterinary Clinical Complex for necessary treatment. Six adult camels aged of 7 to 13 years and of both sexes (3 male and 3 female) were presented with history of fracture of lower jaw. Fracture occurred due to camel fighting (n=1), self inflicted injury (n=2), external trauma by owner (n=2) and unknown cause (n=1). Clinical examination revealed hanging of lower jaw, animals were unable to prehense, drooling of saliva and both the lips became apart due to downward hanging of rostral fracture fragment of lower jaw.

Radiographical examination was performed by both lateral and/or dorso-ventral (DV) views for

SEND REPRINT REQUEST TO H.S. BHABHOR email: drhsbsh@gmail.com

identifying location and type of fracture of rami of mandible. All fractures were across the horizontal ramus and bilateral in nature (Fig 1). Oral cavity was irrigated with 0.2% solution of potassium permanganate and administered pre-operative antibiotics (Oxytetracycline @4mg/kg IV OD) and non-steroidal anti-inflammatory agent (Meloxicam @0.5mg/kg IV OD).

Procedure

Pre-anaesthetic fasting was done for at least 24 hours and before sedation and camels were secured in sitting position. Surgical procedure was done under general anaesthesia using xylazine @ 0.4 mg/kg BW along with Ketamine @ 2 mg/kg BW, intravenously.

Mandibular fracture of animals were immobilised with external skeletal fixation technique (Fig 2-5). A stab incision was given after preparing the aseptic surgical site. A tunnel was drilled with the help of a drill bit (2.5 mm) on either side of fractured fragments using low speed, high torque power drill. The end threaded negative profile pins (3.0 mm) were introduced into the predrilled tunnel and continuously flushed with a sterile normal saline at the site. In rostral fragment, drilling was done between the roots of two adjacent teeth to insert transcortical pins. One transcortical pin in rostral fragment and one pin in caudal fragment was placed. An external fixator / connecting bar was applied with the help of clamps on both side to the lateral surface of the horizontal ramus, with minimum two pins in the rostral fragment and two in the caudal fractured fragment. The proximal and distal mini clamps were attached to the pins and tightened to maintain reduction before confirming the fracture alignment and then the two centre pins were driven into the mandible using their clamps as guides. Excessive length of pins were trimmed using pin cutter and whole ESF assembly was cleaned aseptically and protected with bandaging.

Post-operative Care

Post-operatively, all the animals were administered with inj. oxytetracycline @ 5mg/kg BW I/V, inj. meloxicam @ 0.5mg/kg BW I/M and B-complex, intramuscularly for 7days, 5 days and 5 days, respectively. Antiseptic dressing with povidone iodine solution (2%) was performed on alternate day by flushing the shafts of pins and pin insertion sites. The whole assembly was covered with sterile gauge and bandage. On follow-up, interdental wiring was applied after removal of loosened ESF (under xylazine sedation) where additional support was needed in remaining healing period.

Results and Discussion

Radiographical examination revealed 4 (66.67%) cases of transverse fractures (Fig 1) and 2 (33.33%) cases of oblique fractures of horizontal ramus of mandible and all fractures were bilateral in nature. In 3 (50%) cases of mandibular fracture, the fracture site was anterior to tushes whereas in 2 (33.33%) cases fractures were in between premolars and in 1 (16.67%) case both sides of fracture site were different, i.e. between 2nd premolar and 1st molar tooth at left side and between premolars on right side.

In all cases, the external skeletal fixator assembly provided rigid fixation and adequate support at the fracture site for a particular time period (Fig 5) and all animals were able to prehense and drink water easily after application of ESF assembly (Figs 6, 7).

In present study, fracture union was assessed on the basis of clinical and radiographical examination. External callus formation at the fracture ends at various time interval were noted. An average healing period of mandibular fractures assessed on the basis of clinical and radiographical examination was 10.83±1.11 weeks where compound fracture took more time (10-14 weeks) than simple fracture (6 weeks) for complete healing. The clinical and radiographical union of fractured fragments occurred within 6 weeks in close oblique fracture (n=1) (Fig 8) while 11 weeks in open oblique fracture (n=1) and 10-14 weeks (mean 12±0.82 weeks) in open transverse fractures (n=4). All animals were able to prehense normally (Fig 6).

In present study, loosening of ESF assembly were observed at different time interval in all the cases and later, these were removed. The average removal period of ESF recorded was 5.67±0.76 weeks. Loosening/removal of ESF assembly was observed in 4 weeks (n=2, 33.33%), 5 weeks (n=1, 16.67%), 6 weeks (n=2, 33.33%) and more over 9 weeks (n=1, 16.67%). In 4 (66.67%) cases after removal of ESF, interdental wiring was applied for additional support in remaining healing period. However, in 2 cases (33.33%) after loosening, the ESF assembly was removed but mandible showed clinical union as there was no movement at fracture site hence did not require additional support of IDW. Osteomyelitis was not observed in the cases treated by ESF, clinically and radiographically.

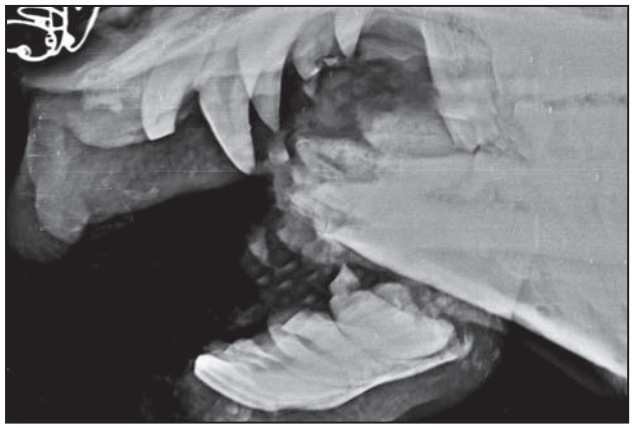


Fig 1. Lateral radiograph of mandible showing transverse fracture of horizontal ramus anterior to tushes. Note the ventrocaudal displacment of rostral fracture fragment.

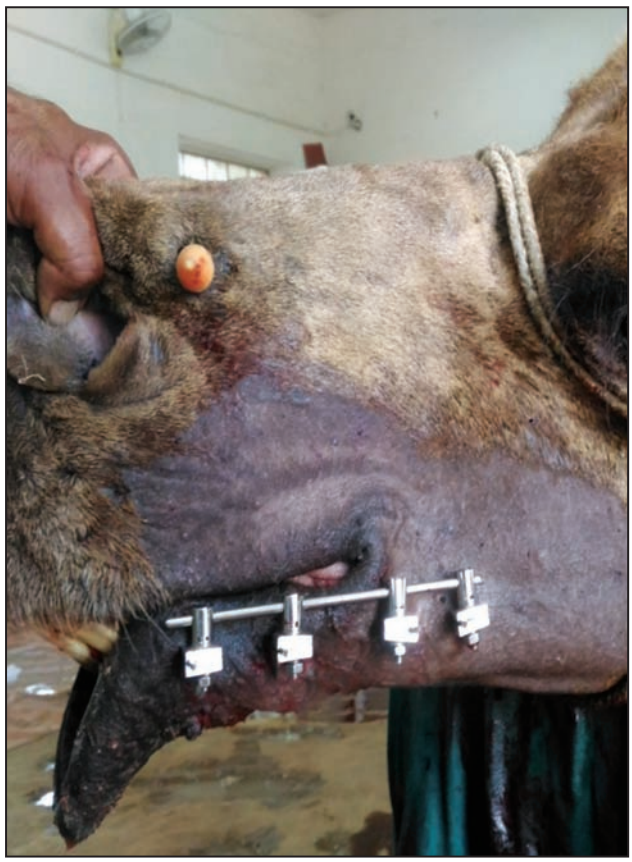


Fig 2. ESF assembly at site after complete reduction of fractured mandible.

In present study, mild discharge at pin insertion site on the skin was recorded in all the cases. Submandibular abscesses were observed in 5 (83.33%) cases and these were lanced and cavity was flushed with light potassium permanganate solution and subsequent aseptic dressing with povidone iodine solution (2%) was done for one week. The submandibular abscesses in all cases healed within 7-10 days.

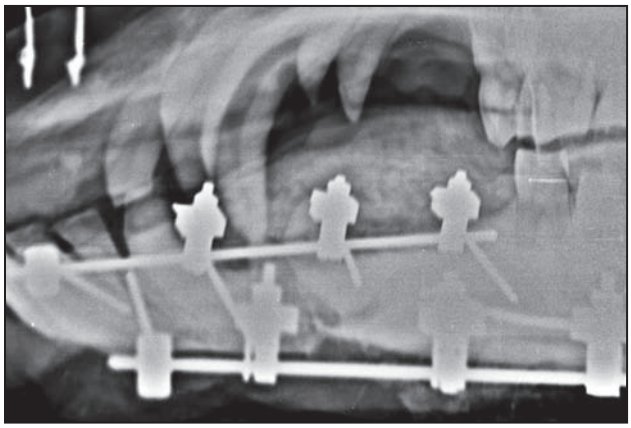


Fig 3. Lateral radiograph showing satisfactory reduction of fractured mandible using ESF device.

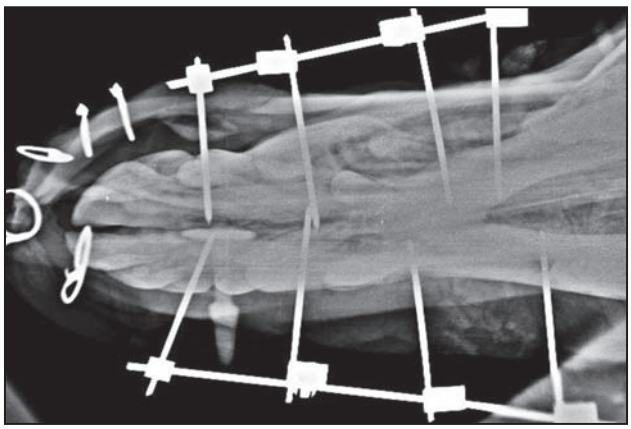


Fig 4. Dorsoventral radiograph showing satisfactory reduction of fractured mandible using ESF device.

External skeletal fixation is a technique of achieving the rigid fixation at the fracture site by percutaneous applied fixation of pins that penetrated the bone internally and externally was connected with connecting bar or clamps. They provided an early return to the function, facilitated the management of soft tissue wounds, helped preserving the local blood flow at the fracture site and allowed ease of implant removal (Vogel and Anderson, 2014).

Similar ESF technique in mandibular fracture was mentioned by Valle *et al* (2018), and Belsito and Fischer (2001) either alone or in combination with either intraoral wiring or lag screw in Mediterranean buffalo and equine, respectively. They reported healing after 10 weeks in Mediterranean buffalo and 38-76 days in horse. However, Parashar and Gahlot (2023) reported fracture healing in 6-8 weeks following transfixation of pins with fibre cast technique along with IDW in camel.

ESF technique efficiently managed not only transverse fractures but also oblique type fractures of

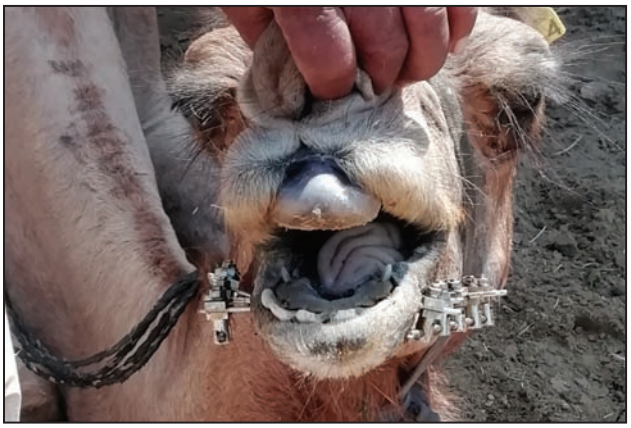


Fig 5. Rigid fixation and reduction provided by ESF assembly in case of mandibular fracture in camel.

Fig 6. Restoration of prehensile function in camel after application of ESF assembly.

Fig 7. A camel after application of ESF assembly was able to drink water conveniently.

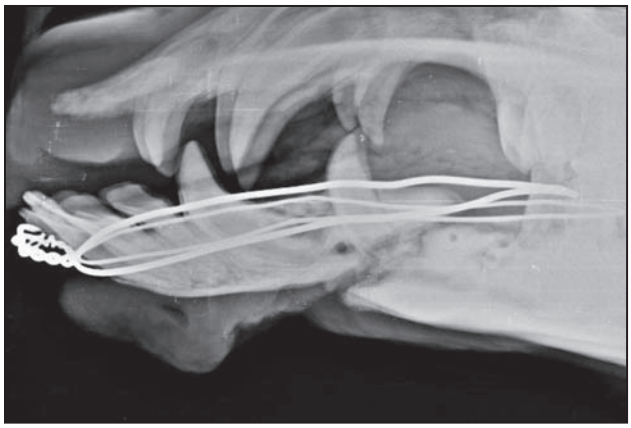


Fig 8. Lateral radiograph at 11th week revealed healing of mandibular fracture after removal of ESF assembly. The ESF was removed and additional support was provided with IDW.

mandible. IDW technique alone was not suitable for immobilisation of oblique fractures due to overriding and shortening of jaw (Gahlot *et al,* 1989; Gahlot, 2000; Parashar and Gahlot, 2023). Similarly, Parashar and Gahlot (2023) also successfully managed the oblique fractures with transfixation pins with fibre cast along with IDW technique.

The loosening of pins occurred due to thermal necrosis of bone at the pin insertion site or due to the infection in post-operative period at the pin insertion site (Singh *et al,* 2020; Smith and Kern, 1995). In this study low speed high torque power drill was used to avoid thermal necrosis of the bone.

Loosening of pin, mild discharge at pin insertion site and development of submandibular abscess (only in compound fracture) was observed during surgical repair of mandibular fractures. Amer (2013), Parashar and Gahlot (2023) and Valle *et al* (2018) also observed pin loosening during fracture healing period. Sub-mandibular abscesses is a common sequel during healing period in compound fracture of mandible (Gahlot *et al,* 1984; Bhabhor *et al,* 2020). In animals of present study osteomyelitis was not seen during healing period but many researchers recorded it during healing of fractures (Ahmed and Al-Sobayil, 2012; Ahmed, 2011; Al-Dughaym *et al,* 2003).

Conclusions

ESF technique is suitable for management of transverse and oblique type of mandibular fractures in camels.

Conflicts of Interest

The authors declare no conflict of interest.

References

Al-Dughaym AM, Ramadan RO, Mohamed GE, Fadlelmula A and Abdin Bey MR. Post-traumatic buccal infection and osteomyelitis with mandibular fracture in the dromedary camel. Journal of Camel Practice and Research. 2003; 10:74-76.

Ahmed AF. Mandibular fracture in single humped camels. Veterinary Surgery. 2011; 40(7):903-907.

Ahmed AF and Al-Sobayil FA. Fractures in young, single-humped camels (*Camelus dromedarius*). Turkish Journal of Veterinary and Animal Sciences. 2012; 63 (1):1-8.

Al-Sobayil F, Sadan MA, El-Shafaey ES and Ahmed AF. Can bone marrow aspirate improve mandibular fracture repair in camels (*Camelus dromedarius*). A preliminary study. The Journal of Veterinary Science. 2020; 21(6):e90.

Amer MSM. Clinical and educational studies on some equine fractures, Doctoral dissertation, submitted to the Cairo University. 2013.

Awwad Tamer E, El-Kammar Mahmoud H, Ahmed Howaida Abu, Korittum Sherif A. Mandibular fracture: a clinical study in dromedary camels. Alexandria Journal of Veterinary Sciences. 2022; 72(1):80-86.

Bhabhor HS and Tanwar M. Imaging studies of cadaver mandible of camel and its correlation with mandibular fracture. Journal of Camel Practice and Research. 2023; 30(3):331-335.

Bhabhor HS, Tanwar M, Palecha S, Bishnoi AK, Kachwaha K, Gahlot TK and Bishnoi P. Surgical management of mandibular fracture in camels using interdental wiring (IDW) technique. Ruminant Science. 2020; 9(10:169-172.

Belsito KA and Fischer AT. External skeletal fixation in the management of equine mandibular fractures: 16 cases (1988-1998). Equine Veterinary Journal. 2001; 33(2):176-183.

Fubini SL and Ducharme NG. Dentistry. In: Farm Animal Surgery. (2nd Edn.). Elsevier. 2017; pp 134-135.

Gahlot TK, Choudhary RJ, Chouhan DS, Chawla SK and Krishnamurthy D. Clinical evaluation of interdental wiring technique for mandibular fracture repair in camels. Indian Veterinary Journal. 1989; 66:251-254.

Gahlot TK. Fracture. In: Selected Topics on Camelids, Gahlot TK (Ed.). Sankhla Printers, Bikaner, India. 2000; pp 382-407, ISBN: 81-901141-0-7.

Gahlot TK. "The camel's lower jaw is unique." Down To Earth. 2005, Jan. 15. 2005.

Gahlot TK, Khatri SK, Chouhan DS, Choudhary RJ and Purohit RK. Repair of transverse mandibular fracture by silver wiring in camels (*Camelus dromedarius*). Indian Journal of Veterinary Surgery. 1984; 5:74-76.

Niwas R, Kumar S, Mathew RV. Surgical Management of Bilateral Mandibular Fracture in Camel by Interdental Wiring. Veterinary Clinical Science. 2020; 08(02):38-39.

Parashar MC and Gahlot TK. Surgical management of mandibular fracture in camels using modified IDW (IDW and transfixation of pins with fibre cast) technique. 2023; 30(3):323-326.

Rastabi HI, Moarabi A, Khajeh A and Kavosi N. Management of a bilateral mandibular fracture in a single-humped camel. Faculty of Veterinary Medicine, Urmia University, Urmia, Iran. Veterinary Research Forum. 2017; 8(2):171.

Siddiqui MI, Telfah MN, Rashid J and Taleb SA. Modified interdental wiring technique for mandibular fractures in camels: A Clinical Study. Journal of Veterinary and Animal Sciences. 2012; 2:57-60.

Singh AP, Singh G, Aithal HP and Singh P. The musculoskeletal system. Section D Fractures. In: Ruminant surgery. 2nd edn, Singh J, Singh S and Tyagi RPS ed. CBS Publishers and Distributors Pvt Ltd. 2020; pp 499-518.

Smith MM and Kern DA. Skull trauma and mandibular fractures. Veterinary Clinics: Small Animal Practice. 1995; 25(5):1127-1148.

Valle DG, Guccione J, Pasolini MP, Ciaramella P and Fatone G. External Skeletal Fixation for Surgical Repair of a Bilateral Mandible Fracture in a Mediterranean Buffalo. Pakistan Veterinary Journal. 2018; 38(4):456-458.

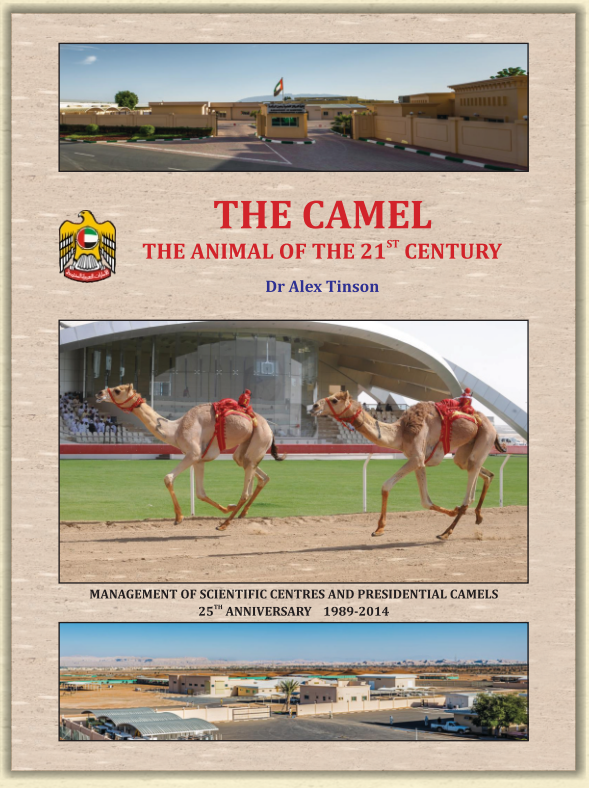
Vogel SR and Anderson DE. External skeletal fixation of fractures in cattle. Veterinary Clinics: Food Animal Practice. 2014; 30(1):127-142.

Zamos DT, Honnas CM, Herman JD, Sanders Elizabeth, Jensen JM and Holcomb JR. Surgical repair of a fractured mandible in an adult camel (*Camelus dromedarius*). Journal of Zoo and Wildlife Medicine. 1992; 23(3): 364-368.

THE CAMEL

THE ANIMAL OF THE 21ST CENTURY

This book authored by Dr Alex Tinson is an acknowledgement to the support and inspiration that His Highness Sheikh Khalifa Bin Zayed Al Nahyan has provided to the centre and to research in general. The last 25 years has been an incredible adventure for us, the noble camel and the people of the U.A.E. Dr Tinson has been involved with many world first's since moving to Abu Dhabi 25 yrs ago. First there was the establishment of pioneering centres in exercise physiology and assisted reproduction. The establishment of the Hilli Embryo Transfer Centre led to five world firsts in reproduction. The world's first successful embryo transfer calf birth in 1990, followed by frozen embryo transfer births in 1994, twin split calves in 1999, pre-sexed embryo births in 2001 and world's first calf born from A.I. of frozen semen in 2013. The hard bound book is spread in 288 pages with 5 chapters. The first chapter involves early history of the centre, world's firsts, world press releases, history of domestication and distribution, evolution of camel racing in the U.A.E. and historical photos the early days. Second chapter comprises camel in health and disease and it involves cardiovascular, haemopoetic, digestive, musculoskeletal, reproductive, respiratory, urinary and nervous systems in addition to the description of special senses. This chapter describes infectious, parasitic and skin diseases in addition to the nutrition. The third chapter is based on Examination and Differential Diagnosis. The fourth chapter is based on special technologies bearing description of anaesthesia and pain management in camels, diagnostic ultrasound and X-Ray, assisted reproduction in camels, drug and DNA testing and surgery. The last chapter entailed future scope of current research.



Author
Dr Alex Tinson

First Edition : 2017

Publisher:
Camel Publishing House
67, Gandhi Nagar West, Near Lalgarh Palace
Bikaner-334001, india
Email : tkcamelvet@yahoo.com

Website:
www.camelsandcamelids.com
www.tkgahlotcamelvet.com

ISBN : 81-903140-5-X
Printed in India

DOI : 10.5958/2277-8934.2024.00013.4 *Vol 31 No 1, p 77-81*

COMPARATIVE ANALYSIS OF PHYSICO-CHEMICAL PROPERTIES OF BUFFALO, CAMEL AND BLENDED (BUFFALO 70%: CAMEL 30%) MILK

Vimala Choudhary[1], Basant Bais[2], Yogesh Kumar[3], Deepika Goklaney[4], Devendra Saran[5], Phool Kanwar[1], Anita Tanwar and Anuj Kumar[1]

[1]Department of Livestock Products Technology, [2]Department of Livestock Production and Management, College of Veterinary and Animal Science, Bikaner (RAJUVAS, Bikaner) Rajasthan

[3]ICAR-National Research Centre on Camel, Bikaner, Rajasthan

[4]Department of Veterinary Public Health & Epidemiology, [5]Department of Veterinary Anatomy, College of Veterinary and Animal Science, Bikaner (RAJUVAS, Bikaner) Rajasthan

ABSTRACT

The present study was conducted on comparative analysis of physico-chemical properties of buffalo, camel and blended milk. The buffalo milk is white in colour with and thick consistency, however, the camel milk is opaque white with salty in flavour. The fat (6.03±0.143%), SNF (9.44±0.016), total solids (15.4±0.156), lactose (5.00±0.091) and protein (3.65±0.050%) of milk was significantly higher in buffalo as compared with camel milk. However, water content (88.40±0.143) and freezing point (-0.519±0.002°C) was significantly higher in camel milk as compared with buffalo milk. The pH of camel milk (6.52±0.006) was more acidic as compared with buffalo milk (6.73±0.012). The physico-chemical properties of blended milk were observed.

Key words: Buffalo, Camel, Blended Milk and Physico-chemical

People living in the arid lands of the world use camel milk as an important source of proteins. Approximately, 2.9 million tones of camel milk are produced annually, globally. Camel milk possess numerous medicinal properties which strengthen it's therapeutic potential against many diseases including autism (Gahlot and Adams, 2023), diabetes, anaemia, jaundice, arthritis, and cancer (Patel *et al,* 2022; Alkattan *et al,* 2023). In recent past, lot of studies were done to compare the camel milk with other domestic large ruminants. The comparison was made between various physico-chemical properties of camel milk with cow and buffalo milk (Yoganandi *et al,* 2015). The physico-chemical and protein profile of milk obtained from local Pakistani breeds of milch animals such as Nilli-Ravi buffalo, Sahiwal cow, Kajli sheep, Beetal goat and Brela camel has also been studied (Yasmin *et al,* 2020). The various physico-chemical parameters of milk of two species, camel and buffalo has been studied (Singh *et al,* 2013). Efforts are made to increase the palatability of camel milk by blending it with other ruminant milk, i.e. cow and buffalo milk. Present study is therefore, planned to compare the diverse physico-chemical parameters of blended milk (buffalo and camel) with buffalo and camel milk.

Materials and Methods

Buffalo milk samples were obtained from a local buffalo dairy farm located on the outskirts of Bikaner, while camel milk samples were collected from the National Research Centre on Camel, Bikaner. A total of 20 milk samples were collected, each promptly sterilised, labelled, and transferred to a container with ice cubes. These containers were immediately transported to the Department of Livestock Products Technology, CVAS, Bikaner (RAJUVAS, Bikaner) in Rajasthan. The samples were appropriately tagged and labeled with information such as the collection date, time, and sample names. Subsequently, the samples underwent analysis for various laboratory tests in triplicate, with readings recorded. Throughout the testing process, strict adherence to hygiene and safety protocols was maintained to prevent any potential contamination.

The physio-chemical properties like colour, odour, consistency, SNF, protein, fat, total solids, and pH were recorded. The pH was measured using digital pH meter (LABMAN pH METER LMPH-10) equipped with a combined glass electrode. Specific gravity was detected by using lactometer

SEND REPRINT REQUEST TO VIMALA CHOUDHARY email: dvimala111@gmail.com

as described by Aggarwala and Sharma (1961). The fat, protein, lactose, freezing point, were determined by the Milkoscan (LM2, Milkotester Ltd., Bulgaria) at milk research laboratory, Department of livestock production and technology, College of Veterinary and Animal Science, RAJUVAS, Bikaner and total solids contents according to A.O.A.C. (1995), and the solids not fat (SNF) and water contents were determined by differences, as indicated:

- SNF content = TS % - Fat %
- % water contain = (100 -%total solids)

Results and Discussion

In present study, the visual inspection of buffalo milk revealed a characteristic whitish colour, consistent with the typical appearance of buffalo milk. On the other hand, camel milk displayed an opaque whitish appearance upon observation. This disparity in colouration between the two types of milk samples was noteworthy and may be attributed to inherent differences in the composition of proteins, fats, and other components in buffalo and camel milk. Opaque white colour present in camel milk was because the fats are finely homogenised throughout the milk (El-Deeb *et al,* 2017). The whitish colour of buffalo milk is a common visual trait associated with the presence of casein proteins, which constitute a significant portion of the milk solids. The blended milk exhibited a colour that was distinct from both individual sources, indicating a blending effect. This finding is in line with the intended composition and reflects the visual integration of buffalo and camel milk characteristics in the composite sample.

The consistency of buffalo milk revealed a notably thick texture, consistent with the common perception of buffalo milk as having a rich and dense consistency. In contrast, camel milk exhibited a comparably thinner consistency, aligning with prior observations of camel milk being generally less viscous. According to a study by Guo *et al* (2016), buffalo milk exhibited significantly higher fat content compared to other milk types, contributing to its denser and creamier consistency. The blended milk exhibited a consistency that was thinner than buffalo milk but thicker than camel milk. This suggests a synergistic effect arising from the combination of the two milks. The thickness of milk is influenced by various factors, including the concentration of milk solids, especially fat and proteins.

The fat content of buffalo, camel, and blended (70% buffalo, 30% camel) milk samples yielded distinctive findings. The fat content of buffalo milk measured was 6.03±0.143% (Table 1), a value consistent with the well-known richness of buffalo milk. In comparison, camel milk had a lower fat content (2.78±0.062%) (Table 1). In blended sample, the fat content was 5.68±0.062% (Table 1). Buffalo milk's higher fat content can be attributed to the specific genetic characteristics of buffalo breeds and their propensity to produce milk with elevated fat levels. According to a study by Cosenza *et al* (2018), certain buffalo breeds genetically produce milk with higher fat content as compared to other dairy animals.

The solid-not-fat (SNF) content in buffalo, camel and blended (70% buffalo, 30% camel) milk samples revealed distinctive compositions. The SNF content of buffalo milk was 9.44±0.016% (Table. 1), reflecting the expected richness associated with buffalo milk. In contrast, camel milk had slightly lower SNF content (8.92±0.034%) (Table 1). The SNF content of the blended milk was 9.26±0.007% (Table 1). The solids-not-fat (SNF) content in milk generally ranges from 8.5% to 9% in cows, approximately 9.5% to 10% in buffaloes 10% to 12% in camel, as indicated by various studies (Oftedal, 1984; Cosenza *et al,* 2018; Konuspayeva *et al,* 2009). The solids-not-fat (SNF) content in milk can be influenced by factors such as species, breed, stage of lactation, and dietary composition (Zicarelli, 2016).

Table 1. Physico-chemical (mean±SE) properties of buffalo and camel milk.

Physico-chemical properties	Buffalo milk (mean±SE)	Camel milk (mean±SE)	Blended milk (Buffalo 70%: Camel 30%) (mean±SE)
Fat %	6.03±0.143	2.78±0.062	5.68±0.062
SNF %	9.44±0.016	8.92±0.034	9.26±0.007
Total solids %	15.4±0.156	11.59±0.143	14.93±0.061
Protein %	3.65±0.050	3.45±0.028	3.52±0.006
Lactose %	5.00±0.091	4.48±0.047	4.90±0.040
Water content %	84.53±0.156	88.40±0.143	85.07±0.061
Freezing point (°C)	-0.548±0.000	-0.519±0.002	-0.535±0.003
pH	6.73±0.012	6.52±0.006	6.62±0.010
Specific gravity	1.032±0.001	1.025±.001	1.028±0.000

The total solids content in buffalo, camel, and blended (70% buffalo, 30% camel) milk samples unveiled noteworthy disparities in their compositions. Buffalo milk had a robust total solids content of 15.4±0.156% (Table 1), aligning with the anticipated

richness associated with this milk type. In contrast, camel milk displayed a comparatively lower total solids content at 11.59±0.143% (Table 1). The blended milk had a total solids content of 14.93±0.061% (Table 1). The total solids content in milk varied from 12 to 13% in cows, 16 to 17% in buffaloes and 10 to 12% in camels (Hayes *et al,* 2011; Haenlein and Caccese, 2006; Konuspayeva *et al,* 2009). Variations in the total solids content of milk are influenced by factors such as breed, nutrition, and lactation stage (Shamsia, 2016). Changes in total solids content in milk, whether increased or decreased, can influence properties such as viscosity and nutritional value, with specific effects owing to factors like fat and protein content (Albenzio *et al,* 2019).

The lactose content, buffalo milk exhibited a value of 5.00±0.091%, while camel milk showed a slightly lower lactose content at 4.48±0.047%. The blended milk, combining 70% buffalo and 30% camel milk, demonstrated a lactose content of 4.90±0.040%. The lactose content in milk varies among species, with approximate ranges as follows: in cows (4.8% to 5.1%), buffalo (4.8% to 5.2%), camel (4.5% to 5.5%), (Haenlein, 2007). The sweatness of buffalo milk due to the presence of higher content of lactose in buffalo milk (Parker *et al,* 2010), however, the saltyness taste of camel milk is due to the lower amount of lactose content in camel milk (Szilagyi, 2015).

The protein content buffalo milk was 3.65± 0.050%, while camel milk exhibited a slightly lower protein content (3.45±0.028%). The blended milk, a combination of buffalo and camel milk, demonstrated a protein content of 3.52±0.006%. Protein content in milk varies among species, ranging approximately from 3.2% to 3.5% in cows, 3.3% to 4.2% in buffalo, 2.9% to 3.5% in camel (Haenlein, 2007). The higher protein content in buffalo milk compared to camel milk can be attributed to the differences in the amino acid composition and casein micelle structure of the two milks. Buffalo milk, like cow milk, is characterised by a higher casein content, which contributes to its overall protein content. Additionally, the specific amino acid profile of buffalo milk proteins may be different from that of camel milk, influencing the overall protein concentration (Haenlein, 2007).

The water content percentages were 84.53± 0.156% for buffalo milk, 88.40±0.143% for camel milk, and 85.07±0.061% for the blended milk. Camel milk generally has a higher water content than buffalo milk due to differences in the composition of these milks, particularly in terms of fat and protein contents (Farah *et al,* 2007). The approximate water percentages in milk also vary, i.e. cow's milk 87% (Bijlani and Joshi, 1985), buffalo's milk 82-86% (Guinee *et al,* 2004), camel's milk 87-90% (Konuspayeva *et al,* 2009).

The freezing points observed were -0.548±0.091°C for buffalo milk, -0.519±0.002°C for camel milk, and -0.535±0.003°C for the blended milk. The elevated freezing point in camel milk aligns with its lower fat content, and the blended milk's freezing point falling between the individual types illustrates the blending effect on achieving an intermediary freezing point. The freezing point of milk is primarily determined by its water content, with lactose concentration acting as a key factor

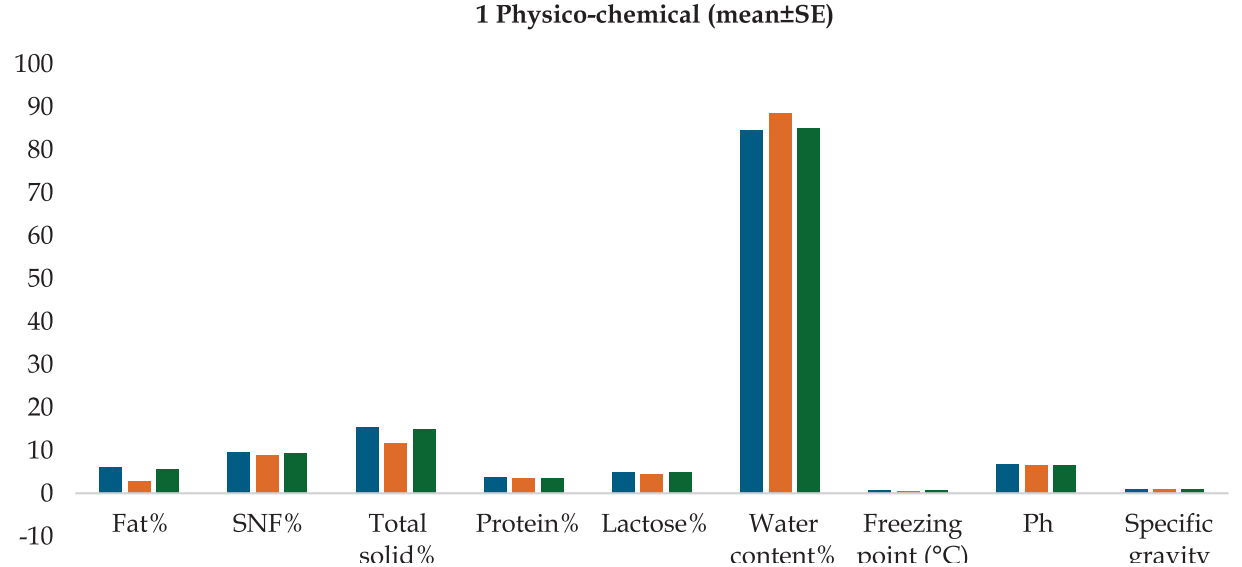


Fig 1. Physico-chemical (mean±S.E.) properties of buffalo and camel milk.

contributing to the depressant effect on the freezing point (IDF Standard 152A, 1995a; Hayes & Prosser, 1973). The freezing point depression (FPD) of milk varies among species, with approximate values for cow's milk around -0.520°C (Fox *et al,* 2000), buffalo's milk around -0.520 to -0.530°C (Fox *et al,* 2000), camel's milk around -0.520 to -0.530°C (Konuspayeva *et al,* 2009).

The pH values recorded were 6.73±0.012 for buffalo milk, 6.52±0.006 for camel milk, and 6.62±0.010 for the blended milk. The pH values of various milks were approximately, i.e. cow's milk 6.5 to 6.7, camel's milk 6.4 to 6.6 (Chavez-Servin *et al,* 2008) and buffalo's milk 6.7 to 7.0 (Seth *et al,* 2016). Camel milk typically has a higher pH than buffalo milk due to differences in protein composition and buffering capacity (Konuspayeva *et al,* 2009; Guinee *et al,* 2015).

Specific gravity values were 1.032±0.001 for buffalo milk, 1.025±0.001 for camel milk, and 1.028±0.000 for the blended milk. The specific gravity of milk varies among species, with approximate values for cow's milk around 1.028 to 1.033 (Marshall, 1993), buffalo's milk around 1.031 to 1.034 (Park *et al,* 2007), camel's milk around 1.030 to 1.033 (Konkuspayeva *et al,* 2009). The specific gravity of buffalo milk is higher than that of camel milk due to differences in fat content and protein composition (Konuspayeva *et al,* 2009).

Conflicts of Interest

The authors declare no conflict of interest.

References

Aggarwala AC and Sharma RM. A Laboratory Manual of Milk Inspection. 4th Ed. Asia Publishing House, Bombay, India. 1961.

Albenzio M, Santillo A, Kelly AL and Caroprese M. Influence of goat farming system on milk fatty acid composition and sensory properties. Small Ruminant Research. 2019; 176:74-79.

Alkattan Abdullah, Alkohaidan Mohamed, Afzal Sheryar, Abdul Manap Aimi Syamima and Kandeel Mahmoud. Camel milk and it's applications in treatment of diabetes: systematic review and meta-analysis. Journal of Camel Practice and Research. 2023. 30(3)257-265.

AOAC. Association of Official Agriculture Chemists. Official Methods of Analysis. 10th ed. Published by the A.O.A.C., Washington, D.C., USA. (1995)

Bijlani RL and Joshi SC. Nutrient composition of Indian foods (Vol. 41). National Institute of Nutrition, Indian Council of Medical Research. 1985.

Chavez-Servin JL, Castañeda-Ovando A, Gallegos-Robles MA and Sánchez-Vega R. Composition and properties of raw milk. In A. Y. Tamime (Ed.), Milk Processing and Quality Management (pp 11-48). John Wiley & Sons. 2008.

Cosenza G, Guarino AM, Anastasio A, Di Palo R, Campanile G and Zicarelli L. Comparative analysis of milk fatty acids and cholesterol content in two Italian Mediterranean buffalo (Bubalus bubalis) breeds. Animals. 2018; 8(8):127.

DADF. Department of Animal Husbandry, Dairying and Fisheries Ministry of Agriculture and Farmers Welfare Government of India, Annual Report. (2018-19). 2019.

Dasharath Patel, Suneeta Pinto, Mahendra Pal. A Comprehensive Review on the Properties of Camel Milk and Milk Products. International Journal of Food Science and Agriculture. 2022; 6(2):200-207. DOI: 10.26855/ijfsa.2022.06.010

El-Deeb A, Dyab A and Elkot W. Production of flavoured fermented camel milk. Ismailia Journal of Dairy Science and Technology. 2017; 5(1):9-20.

Farah Z, Mollet M and Younan M. Camel dairy in Africa: a tool for poverty reduction and food security. Small Ruminant Research. 2007; 69(1-3):62-74.

Fox PF, McSweeney PLH and Cogan TM. Cheese: Chemistry, physics and microbiology: Major cheese groups (Vol. 2). Springer Science & Business Media. 2000.

Gahlot Tarun Kumar and Adams Christina. Camel milk and other dietary treatments in autism: an overview. Journal of Camel Practice and Research. 2023. 30(2)143-147.

Guinee TP, Caric M, Kalab M and Hynes ER. Relationships between the composition, coagulation and rheological properties of milk from different species: a review. International Dairy Journal. 2015; 51:1-12.

Guinee TP, Kelly J and Fox PF. Indigenous milk enzymes: overview and historical aspects—part 1. International Journal of Dairy Technology. 2004; 57(3):129-145.

Guo M, Zhang N, Wu J, Zhou J and Ou Y. Physicochemical properties, microstructure, and in vitro digestion of donkey milk fat emulsions: A comparison with cow milk fat. Food Chemistry. 2016; 212:695-703.

Haenlein GFW. A brief history of goat milk and goat milk products. Small Ruminant Research. 2007; 68(1-2):3-6.

Haenlein GFW and Caccese R. Goat milk versus cow milk. Small Ruminant Research. 1984; 1(2):151-162.

Haenlein GFW and Caccese R. Goat and sheep milk products in human nutrition. Small Ruminant Research. 2006; 68(1-2):126-136.

Hayes HC, Givens DI and Hickey MC. Effects of feeding system on the composition of cow's milk: A review. Journal of Applied Animal Nutrition. 2011; 1, e3.

Hayes JF and Prosser CG. The freezing point of milk. Journal of Dairy Research. 1973; 40(3):297-311.

IDF (International Dairy Federation). Milk: Determination of freezing point - Thermistor cryoscope method. IDF Standard 152A. 1995.

Kohler-Rollefson I and Rathore HS. The Case of the Kumbhalgarh Wildlife Sanctuary and Camel Pastoralism in Rajasthan (India). Sustainability. 2021; 13(24):13914.

Konuspayeva G, Faye B and Loiseau G. The composition of camel milk: a meta-analysis of the literature data. Journal of Food Composition and Analysis. 2009; 22(2):95-101.

Marshall RT. Standard Methods for the Examination of Dairy Products (16th ed.). American Public Health Association. 1993.

Oftedal OT. Milk composition, milk yield and energy output at peak lactation: A comparative review. Symposium on The Nutrition of Herbivores. 1984; pp 151-180.

Park YW, Juárez M, Ramos M and Haenlein GFW. Physico-chemical characteristics of goat and sheep milk. Small Ruminant Research. 2007; 68(1-2):88-113.

Parker M, Zobrist S and Buttrey S. Perceived sweetness and red sweetness-enhancing compounds in milk and milk substitute. Journal of Dairy Science. 2010; 93(8):3272-3283.

Seth R, Prasad A and Singh SK. Buffalo Milk and its Processing. In R. Seth, A. Prasad, & S. K. Singh (Eds.), Buffalo Production and Processing. 2016; (pp 29-39). Springer

Shamsia SM. Characteristics of mare milk and its potential benefit on human health. NFS Journal. 2016; 3:27-31.

Singh KM, Singh P, Sinha N and Ahmad N. An Overview of Livestock and Dairy Sector: Strategies for Its Growth in Eastern Indian State of Bihar. Dr Rajendra Prasad Central Agricultural University, Pusa. 2020.

Singh, Shi & Poonia, Rakesh & Singh, Raghvendar & Mehta, S and Patil Niteen. A Comparative Study on the Physicochemical Parameters of Camel and Buffalo Milk. Journal of Buffalo Science. 2013; 2:135-137. 10.6000/1927-520X.2013.02.03.5.

Szilagyi A. Adaptation to Lactose in Lactase Non-Persistent People: Effects on Intolerance and the Relationship between Dairy Food Consumption and Evaluation of Diseases. Nutrients. 2015; 7(8):6751-6779.

Yasmin I, Iqbal R, Liaqat A, Khan WA, Nadeem M, Iqbal A, Chughtai MFJ, Rehman SJU, Tehseen S, Mehmood T, Ahsan S, Tanweer S, Naz S, Khaliq A. Characterization and Comparative Evaluation of Milk Protein Variants from Pakistani Dairy Breeds. Food Science of Animal Resources. 2020; 40(5):689-698. doi: 10.5851/kosfa.2020.e44. Epub 2020 Sep 1. PMID: 32968722; PMCID: PMC7492176.

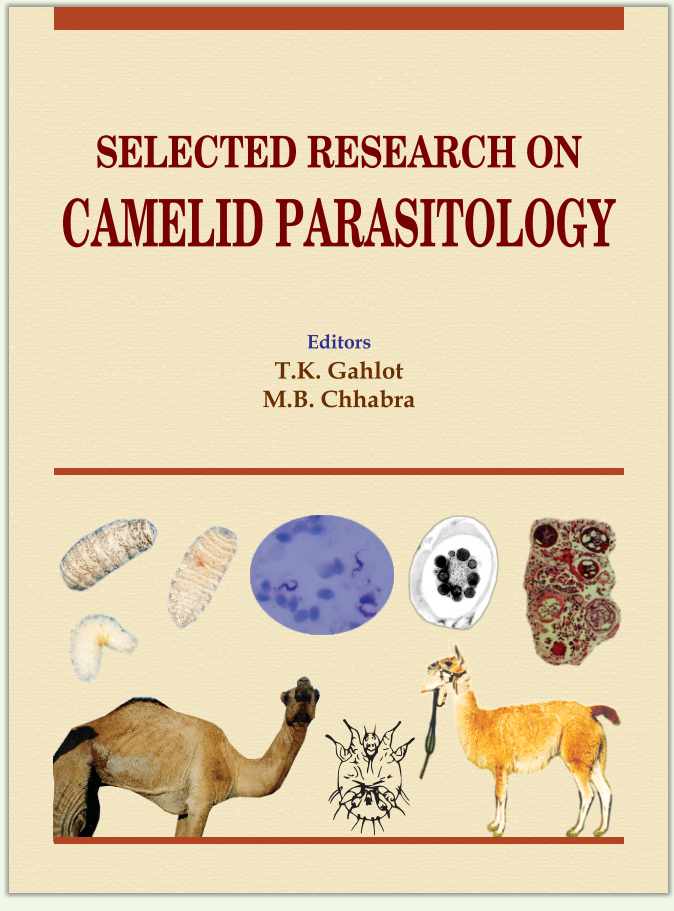
Yoganandi, Jaydeep & Mehta, Bhavbhuti & Wadhwani, K & Darji, Vijay and Aparnathi, Kishorkumar. Comparison of physico-chemical properties of camel milk with cow milk and buffalo milk. Journal of Camel Practice and Research. 2015; 21:253-258. 10.5958/2277-8934.2014.00045.9.

Zicarelli L. Factors affecting the composition of buffalo milk and their effects on dairy products. In: Buffalo Production and Research. 2016; pp 77-94. Wageningen Academic Publishers.

SELECTED RESEARCH ON
CAMELID PARASITOLOGY

Hard bound, 291 pages, few figures coloured

New research and experience always broaden our knowledge, and help us adopting new diagnostic methods and treatments. Camel Publishing House has taken a step forward to compile this knowledge in form of a book and this Herculian task was accomplished with the help of dedicated editors. viz. Drs. T.K. Gahlot and M.B. Chhabra. ***Selected Research on Camelid Parasitology*** is most comprehensive guide to Camelid Parasitology. The classic reference book serves as a one stop resource for scientific information on major aspects of Camelid Parasitology. Featuring abundant photographs, illustrations, and data, the text covers camelid protozoa, helminths, and arthropods of dromedary and New World camelids. This hard bound book of 304 pages contains seroepidemiological studies, immunological and other diagnostic procedures, and new treatments of parasitic diseases. There are at least 17 countries involved in camelid parasitology research, viz. Ethiopia, France, India, Iran, Jordan, Kenya, Libya, Mauritania, Nigeria, Sultanate of Oman, Pakistan, Saudi Arabia, Sudan, Sweden, United Arab Emirates, Uganda and U.S.A. As per published papers in Journal of Camel Practice and Research (JCPR), 173 authors have contributed 72 manuscripts which are appropriately placed in 5 sections. The text of each manuscript published previously in JCPR remains the same except the pattern of numbering the references in the body of text. This book indicates a swing of camelid research during period 1994-2008 and will help identifying the missing links of research in this subject.



Editors:
T.K. Gahlot and M.B. Chhabra

Edition: 2009

Publisher: **Camel Publishing House**
67, Gandhi Nagar West,
Near Lalgarh Palace
Bikaner 334001 Rajasthan,
India
email: tkcamelvet@yahoo.com
website: www.camelsandcamelids.com

Price: US$ 200 (Abroad)
INR 3000 (India)

ISBN: 81-903140-0-9

DOI : 10.5958/2277-8934.2024.00014.6 Vol 31 No 1, p 83-86

Case Report

BILATERAL GIANT SUBCUTANEOUS LIPOMAS IN ONE-HUMPED CAMEL (*Camelus dromedarius*)

Zabady MK[1,2], Abu-Seida AM[3,2], Al-Hizab FA[4], Hasseeb MM[5] and Al-Saad A[6]

[1]Department of Clinical Sciences, College of Veterinary Medicine, King Faisal University

[2]Department of Surgery, Anesthesiology and Radiology, Faculty of Veterinary Medicine, Cairo University, Giza, PO: 12211, Egypt

[3]Animal Research Facility, Galala University. Suez, Egypt

[4]Department of Pathology, College of Veterinary Medicine, King Faisal University

[5]Department of Pathology, Alexandria University. Alexandria, Egypt

[6]Veterinary Teaching Hospital, King Faisal University. Al-Hasa, 31982, P.O. Box: 400, Kingdom of Saudi Arabia

ABSTRACT

A 10-year-old female Omani one-humped camel with two enormous subcutaneous masses above the base of the tail was admitted to the Veterinary Teaching Hospital (VTH), King Faisal University Saudi Arabia. The two giant masses grew slowly over two years. The body condition score (BCS) of the female camel was between 3.5 and 4 and all clinical parameters were within normal ranges. The circumference of the right and left masses was 79 and 76 cm, respectively. Clinically, the masses appeared doughy, painless and pedunculated with a short wide stem above and around the base of the tail. Both masses had nearly identical sizes, shapes and locations. They looked like the ovine fatty tail. The masses were excised surgically at two separate occasions, one month apart. The surgeries were carried out under the effect of intravenous xylazine HCl 2% solution and ketamine HCl 10% solution as well as ring blocks analgesia. Cut sections of the excised masses showed many yellowish and whitish fat lobules. The weight of the left and right tumours was 6.5 and 6.6 Kg, respectively. Histopathology revealed lobulated groups of the neoplastic adipocytes separated by bands of fibrous tissue elements. The overall appearance of two sections from each mass was consistent with a diagnosis of lipoma. The animal was followed up for 6 months by telephone conversation with the owner and no recurrence of the tumours or complications were recorded.

Key words: Adipocytes, Dromedary camel, Lipoma, Surgery, Tail

Skin and subcutaneous tissue neoplasms are the most often identified neoplastic illnesses in most domestic animals like cattle and buffaloes (Fouad *et al,* 2001), equine (Abu-Seida *et al,* 2003), sheep (Fouad *et al,* 2001; Zabady *et al,* 2004; Abu-Seida, 2015), goats (Abu-Seida and Ahmed, 2007) and dogs (Abu-Seida *et al,* 2008; Abu-Seida and Saleh 2016). There are almost 30 distinct types of cutaneous tumours diagnosed. These are divided into four types: epithelial, mesenchymal, lymphohistiocytic and melanocytic neoplasms. The top ten most frequent neoplasms include mast cell tumours, squamous cell carcinomas, perianal gland adenomas, lymphomas, benign melanomas, haemangiosarcomas, sebaceous gland adenomas, fibrosarcomas, lipomas and malignant melanomas (Mukaratirwa *et al,* 2005).

The Veterinary Teaching Hospital of Qassim University, Saudi Arabia evaluated the incidence, kinds and locations of tumours in 9576 dromedary camels. Histological examination verified tumours in 59 cases with an incidence of 0.006%. Squamous cell carcinoma, fibroma and adenocarcinoma were the common types of tumours occurring in camels (Alsobayil *et al,* 2018).

In dromedary camels, skin and subcutaneous neoplasms are uncommon and constitute approximately 1.3% of the examined camels (Elmaghraby *et al,* 2023). In a recent survey, skin neoplasms include myxosarcomas (0.7%), lipomas (0.2%), papilloma (0.1%), fibropapilloma (0.1%), adenoma (0.1%) and squamous cell carcinoma (0.1%) in 988 examined camels (Elmaghraby *et al,* 2023).

A lipoma is a slow-growing benign fatty tumour that is often seen in the subcutaneous tissues. It feels doughy, fluctuating and is typically painless (Kaswan *et al,* 2013).

Lipoma rarely occurs in camels (Al-Sobayil and El-Amir, 2013; Kaswan *et al,* 2013). It was diagnosed as a rounded to oval swelling with rough surface at

SEND REPRINT REQUEST TO ABU-SEIDA AM email: ashrafseida@cu.edu.eg & ashrafseida@yahoo.com

the dorsal aspect of hock joint (Al-Sobayil and El-Amir, 2013) in female dromedary camel and as a small swelling in the left ischiorectal fossa in a 7-year-old male camel (Kaswan *et al,* 2013). However, bilateral gigantic subcutaneous lipomas around the base of the tail in a 10-year-old female one-humped camel is reported here.

Case description

A 10-year old female dromedary camel was referred to VTH–King Faisal University for two huge bilateral masses around the base of the tail. The clinical parameters of the animal were within normal range. The two masses were small and gradually increased in size over two years. Both masses had nearly identical sizes, shapes and locations. They appeared, if fused together, as the ovine fatty tail or a huge heart-shaped mass covering the upper third of tail. The female camel couldn't move her tail properly. The BCS of the female camel was between 3.5 and 4. The two huge masses were doughy, painless and encapsulated. The masses were not attached to the perineum region resembling the ovine fatty tail (Fig 1). Each mass had a wide peduncle above and around the base of tail. The circumference of right and left masses was 79 and 76 cm, respectively. The skin over the masses was apparently normal with slight alopecia.

Each mass was surgically excised separately (one month apart) starting with the left mass. Feed was withdrawn for 48 hours prior to surgery. The camel was given 0.2mg/kg body weight xylazine HCl 2% and 0.8mg/kg ketamine HCl 10% intravenously. Then, the animal was secured in sternal recumbency. Additionally, ring block analgesia at the stem of the tumour mass was conducted using 30 mL of 2% lidocaine HCl solution.

The skin over the tumour mass and surrounding area was routinely prepared for aseptic surgery. Circular incision was made at the base of tumour mass. Haemorrhage was controlled using thermocautery unit and ligation using vicryl suture material no. 0. Tumour mass was removed by blunt dissection. The subcutaneous tissue was opposed using vicryl no. 1 in a continuous pattern. The skin edges were closed using silk no. 2 and horizontal mattress pattern. Postoperatively, long acting oxytetracycline was injected intramuscularly at a dose of 10mg/kg every 72 hours for two times. Moreover, flunixin meglumine was given intramuscularly at a dose of 1.1mg/kg once daily for 7 days. Daily dressing of the wound with povidone iodine solution was performed until removing the stitches after 10 days of surgery.

After one month, the camel returned back to the hospital for excision of the right tumour mass. The skin wound of the excised left mass healed in a good manner (Fig 2a) but the weight of right tumour mass slightly deviated the tail to left side. The right mass was excised in the same procedures of the left one (Fig 2b).

The excised tumours were fatty in consistency and surrounded with a thick fibrous capsule. Cut sections of both tumours reveled white to yellowish multiple fat lobules (Figs 2c&d). The weight of the left and right tumours was 6.5 and 6.6 Kg, respectively. Small tissue samples from both masses were fixed in formalin 10% solution for routine histopathology. Microscopic examination of sections stained with hematoxylin and eosin revealed lobulated groups of neoplastic mature adipocytes separated by bands of fibrous tissue elements (Fig 3a). The neoplastic fat cells were variable in size and shape with some fibrous tissue in between (Figs. 3b&c). The animal was followed up for 6 months by telephone conversation with the owner. No recurrences of the tumours or complications were recorded.

Discussion

Skin tumours were categorised based on histological features as squamous papilloma (4%), fibropapilloma (4%), subcutaneous lipoma (2%), melanocytoma (2%), melanoma (2%), sebaceous gland adenoma (1%) and sebaceous ductal adenoma (1%) as mentioned before (Khordadmehr *et al,* 2016). The total incidence of skin neoplasms varies between countries. It was 15.24% in 105 examined camels in Iran (Khordadmehr *et al,* 2016). However, this incidence was 1.3 % in 988 examined camels in Egypt (Elmaghraby *et al,* 2023).

Camels are less likely to develop benign cutaneous tumours like papilloma, fibropapilloma, lipoma and adenoma (Elmaghraby *et al,* 2023). However, this case report describes, a case of bilateral gigantic subcutaneous lipomas around the base of the tail in a 10-year-old female dromedary camel.

The affected animal was female and females were more affected by skin neoplasm than males as mentioned by previous researchers (Al-Sobayil and El-Amir, 2013; Alsobayil *et al,* 2018). The affected animal was 10 years old but lipomas are usually seen in the middle and old aged animals (Al-Sobayil and El-Amir, 2013; Kaswan *et al,* 2013). However,

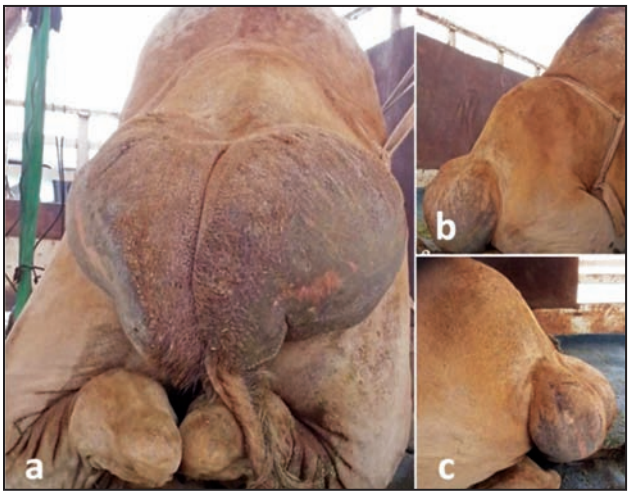


Fig 1. A 10-year-old female camel showing bilateral gigantic lipomas around the base of the tail. (a): Posterior view, (b): Right lateral view and (c): Left lateral view of lipomas.

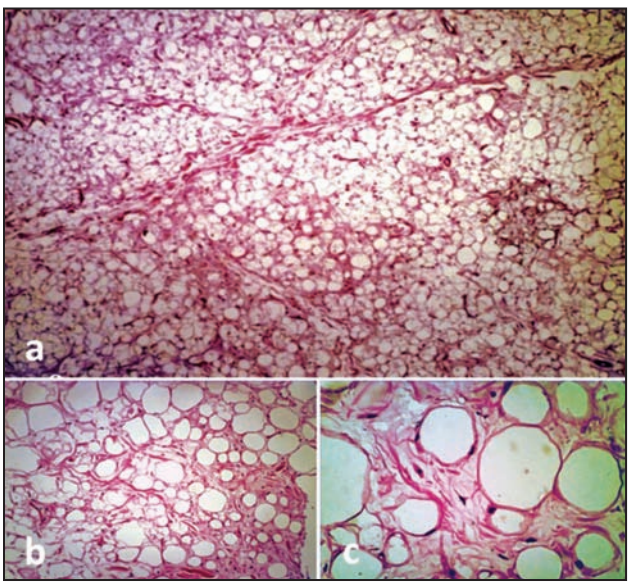


Fig 3. Representative photomicrographs of the excised masses. (a): Photomicrograph showing lobulated groups of the neoplastic adipocytes separated by bands of fibrous tissue elements (H and E, X= 160). (b): Photomicrograph showing variable sized and shaped neoplastic adipocytes separated by fibrous tissue elements (H and E, X= 250). (c): Photomicrograph showing variable sized and shaped neoplastic adipocytes separated by fibrous tissue elements (H and E, X= 400).

Alsobayil *et al* (2018) found that the age of affected camels with various types of neoplasms ranged between 4 months to 18 years.

The BCS of the affected female camel was 3.5-4 BCS. Characteristics of BCS 3.5 included fully developed hump which was 15% higher than chest depth and from the shoulder to the rump but not rounded. However, characteristics of BCS 4 were the same as of BCS 3.5 but the hump was rounded

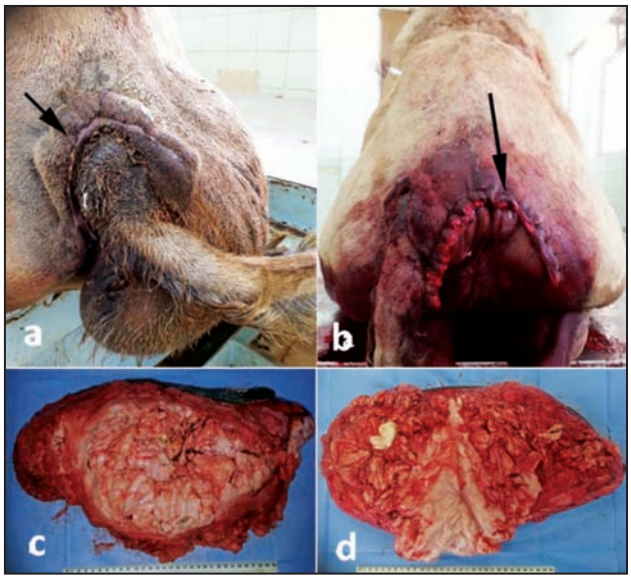


Fig 2. (a): The female camel one month after excision of the left lipoma showing healed skin wound (black arrow). (b) The female camel just after excision of the right lipoma and suture of the skin wound (black arrow). Cut sections in the left (c) and right (d) lipomas showing numerous yellowish white fat lobules.

outwards on both the sides (Singh *et al,* 2016). Therefore, the affected female camel was fatty that might be a predisposing factor for development of lipomas.

Lipomas are present in a variety of body areas. In camels, these were recorded in the ischiorectal fossa (Kaswan *et al,* 2013) and on the dorsal aspect of the hock joint of a Majaheem female-camel (Al-Sobayil and El-Amir, 2013). The present case records lipomas in an unusual location around the base of the tail. In the present case, the two gigantic lipomas appeared as camel's sitting hocks in shape and interfered with tail raising during mating because female camel was raising the tail during oestrus (Khanvilkar *et al,* 2009). Clinical examination of the masses revealed painless, soft and movable lumps. Similar findings were recorded in previous case reports of lipomas in camels (Al-Sobayil and El-Amir, 2013; Kaswan *et al,* 2013).

Surgical excision of the present lipomas was curative and no recurrence or complications were reported till 6 months post-operative. This is in accordance with the findings of previous studies (Al-Sobayil and El-Amir, 2013; Kaswan *et al,* 2013). We preferred to excise the lipomas at two times with one month apart to decrease the stress on the animal and to decrease the blood loss during each surgery.

Interestingly, the excised lipomas reached unusual circumference (76-79 cm) and weight (6.5-

6.6 kg). This could be among the largest-sizes skin neoplasms recorded in camels.

Histpathology is a confirmative diagnosis for tumours and accordingly in the present case it was diagnosed as lipoma. Lipomas have characteristic microscopic features. Lipoma is surrounded by a connective tissue capsule that delivered trabeculae into the tumour mass, separating it into lobules. The tumour is consisted of differentiated fat cells of various sizes and forms (Al-Sobayil and El-Amir, 2013). All of these findings were present in the reported case.

Conflicts of Interest

The authors declare no conflict of interest.

References

Abu-Seida AM. Congenital cutaneous squamous cell carcinoma in a lamb. Asian Journal of Animal Sciences. 2015; 9:80-84. DOI: 10.3923/ajas.2015.80.84

Abu-Seida AM and Ahmed KA. External neoplasms in goats: A clinicopathological study on five types. Veterinary Medical Journal-Giza. 2007; 55(1):33-44.

Abu-Seida AM and Saleh MM. A Gigantic cutaneous fibroadenoma in a dog. Asian Journal of Animal Sciences. 2016; 10(1):113-119. DOI:10.3923/ajas.2016.113.119.

Abu-Seida AM, Gadallah SM, Senna NA and Osman AH. Equine skin neoplasms: Surgical and histopathological studies. Journal of the Egyptian Veterinary Medical Association. 2003; 63(5):131-153.

Abu-Seida AM, Sherein S and Abd-El-Hady. Clinico-pathological aspects of canine skin neoplasms in Egypt. Egyptian Journal of Comparative Pathology and Clinical Pathology. 2008; 21(4):336-356.

Al-Sobayil FA and El-Amir YO. Throughout pathological study on skin, subcutaneous and mucosal neoplasia of the dromedary camel. Brazilian Journal of Veterinary Pathology. 2013; 6(2):48-55.

Alsobayil FA, Ali A, Derar DR, Tharwat M, Ahmed AF and Khodeir M. Tumours in dromedary camels: Prevalence, types and locations. Journal of Camel Practice and Research. 2018; 25(2):189-197. DOI : 10.5958/2277-8934.2018.00026.7

Elmaghraby I, El-Mashad A, Moustafa S and Amin A. Pathological and immunohistochemical studies on skin and subcutaneous neoplasia in Arabian Camels (*Camelus dromedarius*). Kafrelsheikh Veterinary Medical Journal. 2023; 21(1):4-11. DOI:10.21608/kvmj.2023.210014.1034

Fouad KF, Gohar HM, Sheta EM, El-Mahdy M and Abu-Seida AM. A clinicopathological study of some skin neoplasms in ruminants. Journal of the Egyptian Veterinary Medical Association. 2001; 61(5):217-226.

Kaswan BL, Kumar P, Dadhich NK, Kachwaha K, Purohit NR, Tanwar M, Middha A and Gahlot TK. Lipoma in the left ischiorectal fossa of camel-case report. Journal of Camel Practice and Research. 2013; 20(2):317-318.

Khanvilkar AV, Samant SR and Ambore BN. Reproduction in camel. Review. Veterinary World. 2009; 2(2):72-73.

Khordadmehr M, Shahbazi R, Khodakaram-Tafti A and Tavassoli AR. Gross morphology and histopathological features of cutaneous neoplasia in camels (*Camelus dromedarius*). Journal of Camel Practice and Research. 2016; 23(2):309-312. DOI : 10.5958/2277-8934.2016.00051.5

Mukaratirwa S, Chipunza J, Chitanga S, Chimonyo M and Bhebhe E. Canine cutaneous neoplasms: Prevalence and influence of age, sex and site on the presence and potential malignancy of cutaneous neoplasms in dogs from Zimbabwe. Journal of the South African Veterinary Association. 2005; 76:59-62.

Singh S, Vyas S, Nath K and Patil NV. Mating behaviour of one humped camel in relation to body condition. Ruminant Science. 2016; 5(2):235-237.

Zabady MK, Abu-Seida AM and Ahmed KA. Clinico-pathological study on cutaneous squamous cell carcinoma and papilloma in sheep. Veterinary Medical Journal- Giza. 2004; 52(4):589-600.

DOI : 10.5958/2277-8934.2024.00015.8 Vol 31 No 1, p 87-88

Short communication

NAIL AVULSION IN A CAMEL-A CASE REPORT

Amit Sangwan[1], Garima Choudhary[2] and Rajendra Yadav[3]
[1,3]Lala Lajpat Rai University of Veterinary and Animal Sciences, Hisar, Haryana, India
[2]Department of Animal Husbandry Dairying, Haryana, India

Camels are often used for draft or race purposes, which predisposes foot to injury. Camels are taken for open pastures, which may also lead to punctured foot or other foot injuries. Foot disorders and their surgical management in camels have been reported previously (Singh and Gahlot, 1997; Singh et al., 1980; Gahlot, 1984; Gahlot and Chauhan, 1992). However, foot disorders related to the nails of the foot are scarcely reported (Singh and Gahlot, 1997). Present communication deals with the successful surgical management of a case of avulsion of the nail in a dromedary camel.

Case history and treatment

A five year old male camel was presented at Haryana Pashu Vigyan Kendra, Mahendragarh (regional centre of Lala Lajpat Rai University of Veterinary and Animal Sciences, Hisar) with a history of avulsion of the nail in the medial toe of the left forelimb (Fig 1) one week ago due to injury while pulling a cart. The camel had severe pain and could not bear weight on the affected limb. The affected toe was soiled in the sand and appeared as an infected wound. Surgical resection, aseptic bandaging, and proper postoperative care were done, and the animal attained appreciable functionality. It was decided to resect the nail which was caudally attached to coronet.

The animal was kept off feed (for twenty-four hours) and off water (for twelve hours) prior to surgery. The animal was sedated using xylazine at a dose rate of 0.4 mg/Kg body weight, intravenously. Local anesthesia was achieved using 2% lignocaine hydrochloride. After cleaning the wound, the discolored toenail was resected at its caudal attachment to the coronet. The wound was debrided, and povidone-iodine was applied, followed by bandaging of the wound. A gunny bag was wrapped around the foot to protect it from soil contamination. The bandage was changed every alternate day for the first fifteen days for the next 15 days. The animal was administered oxytetracycline @ 5mg/kg wt intravenously for five days and meloxicam 0.2 mg/kg. wt. Intramuscularly for three days, postoperatively.

Fig 1. Severely injured medial toe nail of left forelimb.

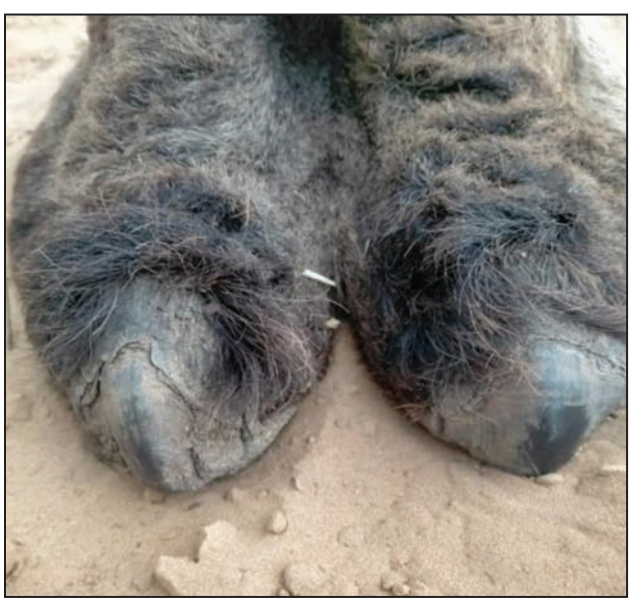


Fig 2. The fully grown medial toe nail 48 weeks post-operatively.

SEND REPRINT REQUEST TO AMIT SANGWAN email: 90amitsangwan@gmail.com

The animal started proper weight bearing and working on the affected limb after one week, but the completely new nail with full strength became evident after one year, postoperatively (Fig 2).

Results and Discussion

The majority of foot affections found in camels are in the age group 5-10 years. However, the animal in the present report was 5 years old. The special anatomy of the foot of a camel permits it to walk through sandy and rough terrains (Bligh *et al,* 1976). The nails in camels are not traumatised so often. Hence reports could not be more detailed on this anatomical part of the foot. However, Singh and Gahlot (1997) have reported avulsion of the nails in camels, and possible etiology ascribed was infection and inflammation of traumatised coronary band. However, in the present case, the most likely etiology was infection and inflammation at the coronet. The treatment in the present case of avulsion of nails was in line with that reported by Singh and Gahlot (1997). However, it was observed in the present case that the formation of a new nail took more than 48 weeks, and keratinisation started from the coronet region. The lameness disappeared with in one week of the avulsion, comparable with the hoof avulsion in cattle (Greenough *et al,* 1981). More clinical studies are needed to understand the etiology and treatment of this rare clinical entity.

Conflicts of Interest

The authors declare no conflict of interest.

References

Abbas B and Tilley P. Pastoral management for protecting ecological balance in Halaib District, Red Sea Province, Sudan. Nomadic Peoples. 1990; 29:77-86.

Abdurahman OASh and Bornstein S. Diseases of camels (*Camelus dromedarius*) in Somalia and prospects for better health.Nomadic Peoples. 1991; 29:104-112.

Al-Ani FK. The musculoskeletal system. In: Camel, Management and Diseases. Al-Sharq Printing Press, Jordan. 1st Edition. 2004; pp 324.

Bligh J, Cloudsley-Thommpson JL and MacDonald AG. Environmental Physiology of Animals. Blackwell, Oxford (Cited by Yagil R, 1993). 1976.

Gahlot TK. Surgical management of deep punctured wounds of foot in camel. Indian Journal of Veterinary Surgery. 1984; 5:140-142.

Gahlot TK and Chouhan DS. Camel Surgery. Gyan Prakashan Mandir ikaner. 992; pp 67-114.

Gauthier-Pilters H and Dagg AI. The Camel: it's Evolution, Ecology, Behaviour and Relationship to Man. Chicago Univ. Press. USA. 1981.

Greenough PR MacCallum FJ and Weaver AD. In: Lameness in Cattle. 2nd Edn, Eds Weaver AD, Wright Scientechnica, ristol, England. 1981; pp 01, 151, 169, 171, 187, 20, 377.

Hjort A and Hussein MA. Camel herd dynamics in southern Somalia: Long term development and milk production implications. Camel Forum. 1986; 18:1-28.

Knoess KH. The camel as a meat and milk animal. World Animal Review. 1977; 22(1):39-44.

Kohler-Rollefson I. The Raika dromedary breeders of Rajasthan: A pastoral system in crisis. Nomadic Peoples. 1992; 30:74-83.

Schwartz HJ. Productive performance and productivity of dromedaries (*Camleus dromedarius*). Animal Research and Development. 1992; 35:86-98.

Siddiqui MI and Telfah MN. Surgical oncology. In: A guide book of camel surgery. Abu Dhabi Food Control Authority (ADFCA). 2010; pp 189. ISBN 978–9948–03–773–6.

Singh AP, Nigam JM and Chandana IS. A radiographic study of foot affections of camel. Haryana Veterinarian. 1980; 19(1):37-41.

Singh Gopal and Gahlot TK. Foot disorders in camels (*Camelus dromedarius*). Journal of Camel Practice and Reseaerch. 1997; 4(2):145-154.

Snow DH, Billah AM, Ridha A and Frigg M. Plasma concentrations of some vitamins in camels. Proceedings of First International Camel Conference Dubai, U.A.E. 1992; pp 335-338.

DOI : 10.5958/2277-8934.2024.00016.X Vol 31 No 1, p 89-94

EFFECT OF GENDER AND AGE OF DROMEDARY CAMEL ON THE NATURE OF DERMOID CYST

Marwa H. Hassan[1,2] and Ashraf M. Abu-Seida[3,2]

[1]Department of Veterinary Clinical Sciences, Faculty of Veterinary Medicine, Jordan University of Science and Technology, Irbid, PO: 22110, Jordan

[2]Department of Surgery, Anaesthesiology and Radiology, Faculty of Veterinary Medicine, Cairo University, Egypt

[3]Galala University, Animal Research Facility, Suez, Egypt

ABSTRACT

Dermoid cyst is more common than other cutaneous cysts in camels. This study recorded the effects of camel's gender and age on the nature of dermoid cysts. A total of 1745 camels (*Camelus dromedarius*) were examined clinically for the presence of dermoid cyst, depending upon its characteristic location and clinical signs as well as paracentesis. A complete case history was taken whenever possible. The affected animal was subjected to thorough clinical examination. Gross examination of the cysts was also performed. The data were statistically analysed. Out of 1745 examined camels, 35 camels (2.01%) had 39 dermoid cysts. All of the recorded cysts were congenital and located at the anterolateral aspect of the cranial third of the neck, just over or near the jugular vein. The affected camels were 21 males and 14 females. The age of diseased camels ranged between one and 16 years. The recorded dermoid cysts located at the right side of neck in 18 camels and at the left one in 13 camels. However, four camels had bilateral dermoid cysts. The cyst appeared as fluctuating, round or oval, painless and movable swelling covered with normal haired skin. Gross examination of the cyst revealed a well-defined, encapsulated sac. The interior of cyst was lined with haired uneven skin and had multiple hair tufts, squamous debris, keratinous material, masses of greasy scales and coffee-coloured fluid. The cysts were either unilocular or multilocular and volume of the cystic contents ranged between 4 and 250 mL. There were no statistically significant associations between the camel's gender and the nature of the dermoid cysts ($P > 0.05$). However, there were statistically significant associations between the camel's age and the nature of the dermoid cysts in terms of volume of the cystic contents and presence of septa ($P < 0.05$). Each one-year increase in the affected camel's age increased the volume of cystic contents by 17.01 mL ($R2 = 0.96$, $P < 0.0001$). In conclusion, dermoid cyst is a common congenital cutaneous cyst in camels and has an identical location as well as characteristic features. The camel's age has an effect on the nature of dermoid cyst in terms of volume of the cystic contents and presence of septa.

Key words: Camel, cutaneous cyst, dermoid cyst, dromedaries, neck swelling, paracentesis

Dermoid cysts are an uncommon developmental aberration that causes focal reduplication of the whole skin structure, including the epidermis and adnexa. They are often congenital, although not always hereditary. Moreover, dermoid cysts appear to affect camels more than other cutaneous cyst (Purohit *et al,* 1989; Ramadan, 1994). Dermoid cysts have been recorded in different animal species and at different locations, mainly in the head and neck regions as shown in Table (1). Dermoid cyst can be single or many, monolocular or multilocular and unilateral or bilateral (Purohit *et al,* 1989; Ramadan, 1994; Abu-Seida and Ahmed, 2007).

Clinically, the cyst appears as a soft, fluctuating, painless, well defined and easily moveable circumscribed swelling of various diameters. The skin above the cyst appears normal (Purohit *et al,* 1989). Aseptic exploratory puncture produces dark thin odourless fluid (Ramadan, 1994; Fouad *et al,* 2001). Sometimes the cyst changes to abscess due to secondary bacterial infection caused by the ignorant intervention by the animal owner (Abu-Seida and Ahmed, 2007).

Ultrasonography, the cyst appears as a sac enclosed by a hyperechoic thick capsule and has heterogenic contents. The contents show a mixture of anechoic fluid and hyperechoic irregular scales and hair (Abu-Seida and Ahmed, 2007).

Under the microscope, the dermoidcyst in camels is lined by an ordered wall of stratified squamous epithelium. The lumen includes tufts of hair, scales and fluid. The basal cell layer has a large number of melanocytes. The dermis also contains sweat and sebaceous glands, as well as hair

SEND REPRINT REQUEST TO ASHRAF M. ABU-SEIDA email: ashrafseida@cu.edu.eg, ashrafseida@yahoo.com

follicles. The epithelial wall invades the dermal-epidermal junction in an attempt to produce a new cyst containing intraluminal keratin. The dermis has sebaceous gland hyperplasia (Fouad *et al,* 2001).

For treatment, careful surgical excision of the dermoid cyst in camels is a curative therapy without recurrence or complications. The excised cyst contains brown thin fluid, hair tufts and grayish greasy scales. The cyst wall is thick, but the interior skin lining is haired, gray and irregular (Purohit *et al,* 1989; Ramadan, 1994; Fouad *et al,* 2001).

There are no data about the effects of gender and age of the affected animals on the nature of dermoid cysts in camels (*Camelus dromedarius*). This study records, for the first time, the effects of camel's gender and age on the nature of dermoid cysts.

Material and Methods

Thepresent study was conducted on 1745 camels (*Camelus dromedarius*) from January 2023 through January 2024. These camels were collected from Berkash camel market and abattoirs in Cairo, Giza and Fayoum Governorates, Egypt. A complete case history was taken whenever possible. The camels were examined for presence of dermoid cyst. The affected camel was subjected to thorough clinical examination. The diagnosis of dermoid cyst was based upon its characteristic location and clinical features as well as paracentesis. Gross examination of the cyst was also performed.

Data were presented as means ± SE for quantitative variables and percentages for qualitative variables. Results were analysed using Pearson's correlation coefficient (*r*), the coefficient of determination (*R2*) (linear regression analysis) and Fisher's Exact test (*FET*) to examine the relationship between variables. PASW Statistics for Windows, Version 18.0.(Chicago: SPSS Inc.) was used for statistical analysis. Significance was set at $P < 0.05$.

Results

Out of 1745 examined camels, 35 camels (2.01%) had 39 dermoid cysts. The obtained case history revealed that all recorded cysts were congenital. Moreover, the cyst started as a firm, non-painful and round mass that grew slowly and became fluctuating

Table 1. Location of the recorded true dermoid cyst in different domestic animal species.

Animals	Locations	References
Camel	At the anteroventral aspect of the cranial third of the neck	Purohit *et al* (1989) Ramadan (1994) Fouad *et al* (2001)
Cattle	At periocular region At the ventral midline of the cranial portion of the cervical area At the nasolacrimal duct At the mandibular gland	Adams *et al* (1983) Baird *et al* (1993) Steinmetz *et al* (2009) Sato *et al* (2023)
Horse	At the temporal area At dorsal midline At the lower jaw	Mason (1974) Hillyer *et al* (2003) Bienert-Zeit*et al* (2011)
Donkey	At the ventral aspect of the cranial third of the neck just caudal to the larynx	Abu-Seida and Ahmed (2007)
Sheep	At the neck region	Jubb and Kennedy (1970)
Goat	Anteroventral aspect of the cranial third of the neck	Gamlem and Crowford (1977)
Dog	At the dorsal skull At the intracranial region At the cervical region At the tongue At the intestine At the abdomen	Alexander (1981) Targett *et al* (1999) Tshamala and Moens (2000) Liptak *et al* (2000) Saberi *et al* (2013) Jones *et al* (2019) Kim *et al* (2022)
Cat	At the spinal cord at the level of the third thoracic vertebra At the intracranial region At the thyroid glands At sublumbar and flank regions At the tail At the nasopharynx At the spinal cord at level of the 7^{th} to 8^{th} thoracic vertebra	Henderson *et al* (1993) Chenier *et al* (1998) Rochat *et al* (1996) Tolbert *et al* (2009) Akhtardanesh *et al* (2012) Koch *et al* (2022) Nishida *et al* (2024)
Pig	At the mammary gland	Günther (1967)

over the time. The affected animals had normal clinical parameters.

All of the recorded cysts were located at the anterolateral aspect of the cranial third of the neck just over or near the jugular vein and had various diameters (Fig 1). Regarding the gender, the affected camels were 21 males and 14 females. The age of diseased camels ranged between one and 16 years. Concerning laterality, the recorded dermoid cysts located at the right side of neck in 18 camels and at the left one in 13 camels. However, four camels had bilateral dermoid cysts.

The cyst appeared as fluctuating, round (n=35) or oval (n=4), painless and movable swelling covered with normal haired skin. Gross examination of the cyst revealed a well-defined, encapsulated sac. The interior of cyst was lined with haired uneven skin and had multiple hair tufts, squamous debris, keratinous material, masses of greasy scales and coffee-coloured fluid. The recorded cysts were either unilocular (n=34) or multilocular (n=5). The volume of the cystic contents ranged between 4 and 250 mL.

Fig 1. Dermoid cyst in camels. Small-, medium- and large-sized cysts at the right side of the cranial third of the neck.

Statistical analysis revealed that there were no statistically significant associations between the camel's gender and the nature of the recorded dermoid cysts ($P > 0.05$) as shown in Table (2). However, there were statistically significant associations between the camel's age and the nature of the recorded dermoid cysts in terms of volume of the cystic contents and presence of septa ($P < 0.05$) as shown in Table (3). There were no statistically significant associations between the camel's age and the shape as well as involvement of the dermoid cysts ($P > 0.05$).

A strong positive correlation was noticed between the camel's age and volume of the cystic contents ($r = 0.98$, $P < 0.0001$) as shown in Fig (2). The linear regression analysis indicated a significant association between the camel's age and the volume of cystic contents of dermoid cyst, where each one-year increase in the affected camel's age increased the volume of the cystic contents by 17.01 mL ($R2 = 0.96$, $P < 0.0001$).

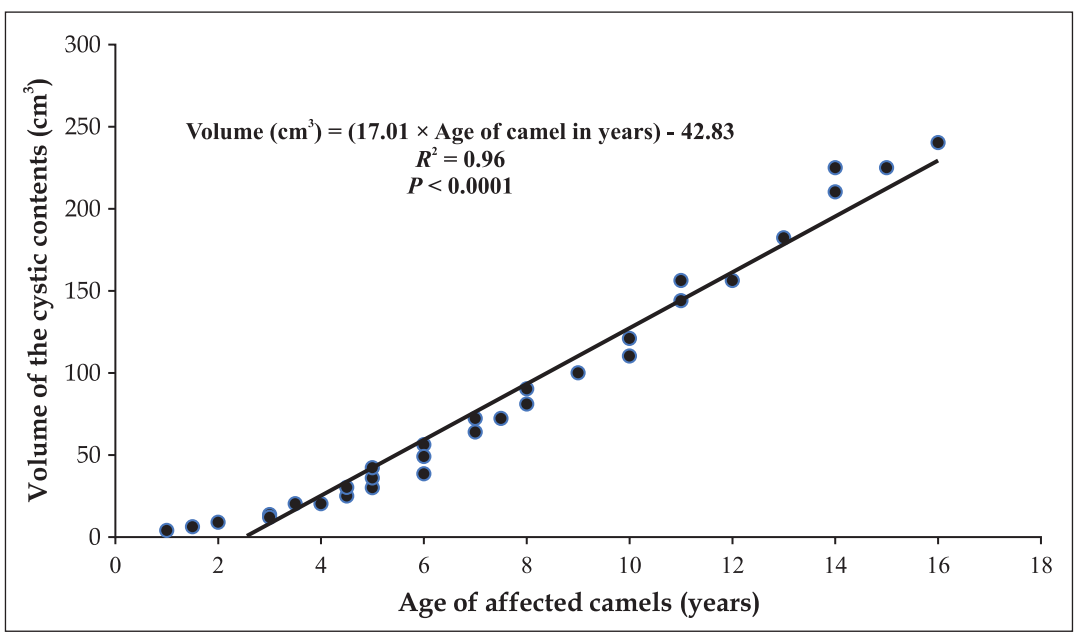


Fig 2. Scatter plot between the age of the affected camels (N=39) and volume of the contents of the recorded dermoid cysts. The equation of regression analysis and the coefficient of determination (R^2) are indicated in the figure ($P < 0.05$).

Table 2. Effect of camel's gender on the nature of the recorded dermoid cysts.

Nature of cysts and age of affected camels		Total number (39)	Gender		P-value
			Female	Male	
Involvement	Bilateral	8	2 (50%)	2 (50%)	1.000
	Unilateral	31	12 (38.7%)	19 (61.3%)	
Shape	Oval	4	1 (25%)	3 (75%)	0.631
	Round	35	15 (42.9%)	20 (57.1%)	
Presence of septa	Multilocular	5	2 (40%)	3 (60%)	1.000
	Unilocular	34	14 (41.2%)	20 (58.8%)	
Volume (mL)	4 to 15	6	2 (33.3%)	4 (66.7%)	0.939
	20 to 50	15	6 (40%)	9 (60%)	
	51 to 100	8	4 (50%)	4 (50%)	
	110 to 250	10	4 (40%)	6 (60%)	

Table 3. Effect of camel's age on the nature of the recorded dermoid cysts.

Nature of cysts		Age (year)					P-value
		Total number (39)	1 to 3.9	4 to 6.9	7 to 10.9	11 to 16	
Involvement	Bilateral	8	0	4 (100%)	0	0	0.113
	Unilateral	31	7 (22.6%)	9 (29%)	8 (25.8%)	7 (22.6%)	
Shape	Oval	4	1 (25%)	3 (75%)	0	0	0.380
	Round	35	6 (17.1%)	12 (34.3%)	9 (25.7%)	8 (22.9%)	
Presence of septa	Multilocular	5	0	0	1 (20%)	4 (80%)	0.004*
	Unilocular	34	7 (20.6%)	15 (44.1%)	8 (23.5%)	4 (11.8%)	
Volume (mL)	4 to 15	6	6 (100%)	0	0	0	< .0001*
	20 to 50	15	1 (6.7%)	14 (93.3)	0	0	
	51 to 100	8	0	1 (12.5%)	7 (87.5%)	0	
	110 to 250	10	0	0	2 (20%)	8 (80%)	

Discussion

Dermoid cysts are more common than other cutaneous cysts in camels (Jubb and Kennedy, 1970; Ramadan, 1994). According to Jubb and Kennedy (1970), dermoid cysts are often slow-growing and asymptomatic unless they develop into an abscess. Similarly, the present findings revealed that the cyst started as a firm, non-painful and round mass that grew slowly and became fluctuating over the time. Moreover, the affected animals had normal clinical parameters.

True dermoid cyst is congenital but not always hereditary and it is caused by aberrant ectoderm and blastoderm folding in embryos (Purohit *et al,* 1989). Gamlem and Crawford (1977) reported dermoid cysts in the same locations on a doe and her progeny, perhaps related to hereditary congenital epithelial dysplasia. In addition, Jubb and Kennedy (1970) found an unconfirmed familial occurrence of dermoid cysts in Merino sheep. Congenital epithelial dysplasia is the most usually proposed explanation. However, there is limited evidence to back up this notion (Gamlem and Crawford, 1977). The affected camels in this study were genetically unrelated, making hereditary causes of the dermoid cyst unlikely. Nevertheless, the recorded dermoid cysts in the present research

are congenital in origin. Rarely, traumatic epidermal implantation might possibly lead to development of dermoid cyst (Jubb and Kennedy, 1970).

Diagnostic imaging modalities like radiography (Steinmetz *et al,* 2009), ultrasonography (Abu-Seida and Ahmed, 2007), computed tomography (Jones *et al,* 2019; Koch *et al,* 2022; Nishida *et al,* 2024) and magnetic resonance imaging (Targett *et al,* 1999; Nishida *et al,* 2024) were used for diagnosis of deep dermoid cyst in different animals. In the present study, we depended upon the characteristic location, clinical features and paracentesis findings because they are confirmative for diagnosis of dermoid cyst.

The present results revealed that the total incidence of dermoid cyst in camels is 2.01%. Nearly similar finding (2.06%) was previously recorded by earlier authors (Fouad *et al,* 2001). All clinical signs and gross findings of the recoded dermoid cysts are similar to those previously mentioned in the veterinary literature (Purohit *et al,* 1989; Ramadan 1994; Fouad *et al,* 2001). Also both males and females are affected with dermoid cyst with no significant difference between them.

Although the camel's age had an effect on the nature of the dermoid cyst in the affected camels, the camel's gender had no effect. The current results revealeda strong positive correlation between the camel's age and volume of the cystic contents. This is in agreement with Purohit *et al* (1989) who recorded that the diameter of dermoid cyst in camels varies from 5 cm up to 15 cm, depending upon the time of development. This finding could be attributed to the continuous secretion of the sweat and sebaceous glands and accumulation of the dropped hair, tissue debris and scales inside the cyst.

Regarding presence of septa inside the dermoid cyst, there was statistically significant association between the camel's age and presence of septa ($P < 0.05$). This could be attributed to development of daughter cysts inside the original one over the time. Microscopically examined dermoid cyst in a donkey showed presence of a daughter cyst with characteristic intraluminal keratin laminations (Abu-Seida and Ahmed, 2007). Moreover, several studies recorded multilocular dermoid cysts in camels (Purohit *et al,* 1989; Ramadan 1994; Fouad *et al,* 2001).

Although surgical excision of the dermoid cyst is an efficient treatment, careful dissection of the cyst from its neighbouring vital structures is highly recommended due to its critical location just over or near the jugular vein (Ramadan, 1994; Fouad *et al,* 2001).

Conclusions

Dermoid cyst is a common congenital cutaneous cyst in camels with an incidence of 2.01%. Dermoid cysts have an identical location on the anterolateral aspect of the cranial third of the neck and characteristic features. The camel's gender has no effect on the nature of the dermoid cysts. However, the camel's age has an effect on the nature of the dermoid cysts in terms of volume of the cystic contents and presence of septa. Each one-year increase in the affected camel's age increased the volume of cystic contents by 17.01 mL.

Conflicts of Interest

The authors declare no conflict of interest.

References

Abu-Seida AM and Ahmed KA. Dermoid cysts in donkeys. Veterinary Medical Journal-Giza. 2007; 55(1):25-32.

Adams SB, Horstman I and Hoerr FJ. Perioculardermoid cyst in a calf. Journal of the American Veterinary Medical Association. 1983; 182(11):1255-1256.

Akhtardanesh B, Kheirandish R and Azari O. Dermoid cyst in a domestic shorthair cat. Asian Pacific Journal of Tropical Biomedicine. 2012; 2:247-249. doi: 10.1016/S2221-1691(12)60051-3.

Alexander RW. Dermoid cysts in dogs. Veterinary Records. 1981; 109(23):521-522.

Baird AN, Wolfe DF and Groth AH. Dermoid cyst in a bull.Journal of the American Veterinary Medical Association. 1993; 202(2):298.

Bienert-Zeit A, Reinig A, HelligeM, Reichert C, Hewicker-Trautwein M and Feige K. Dermoid cyst in the area of the lower jaw in a 7-year-old gelding.Tierarztl Prax Ausg G Grosstiere Nutztiere. 2011; 39(6):397-401.

Chenier S, Quesnel A and Girard C. Intracranial teratoma and dermoid cyst in a kitten. Journal of Veterinary Diagnostic Investigation. 1998; 10:381-384. doi: 10.1177/104063879801000417.

Fouad KA, Gohar HM, Sheta EM, El-Mahdy M and Abu-Seida AM. Dermoid cysts in camels. Journal of the Egyptian Veterinary Medical Association. 2001; 61(6):255-260.

Gamlem T and Crawford TB. Dermoid cysts in identical locations in a doe goat and her kid. Veterinary Medicine: Small Animal Clinician. 1977; 72(4):616-617.

Günther M. Dermoidal mammary cysts in mother pigs. Monatsheftefür Veterinärmedizin. 1967; 22(3):96-98.

Henderson JP, Pearson GR and Smerdon TN. Dermoid cyst of the spinal cord associated with ataxia in a cat. Journal of Small Animal Practice. 1993; 34:402-404. doi: 10.1111/j.1748-5827.1993.tb02734.x

Hillyer LL, Jackson AP, Quinn GC and Day MJ. Epidermal (infundibular) and dermoid cysts in the dorsal midline of a three-year-old thoroughbred-cross gelding. Veterinary Dermatology. 2003; 14(4):20520-9. doi: 10.1046/j.1365-3164.2003.00345.x.

Jones S, Adin C, Thompson E, Robertson I and Rivas R. Computed tomography for the diagnosis and characterisation of dermoid sinuses in two dogs. Journal of the American Animal Hospital Association. 2019; 55(4):e55403. doi: 10.5326/JAAHA-MS-6891.

Jubb KVF and Kennedy PC. In Pathology of Domestic Animals, 2nd edn, Vol. 2, pp 639. NewYork and London: Academic Press. 1970.

Kim D, Dobromylskyj MJ, O'Neill D and Smith KC. Skin masses in dogs under one year of age. Journal of Small Animal Practice. 2022; 63(1):10-15. doi: 10.1111/jsap.13418.

Koch L, Csebi P, Lipnik K and Gradner G. Pharyngeal dermoid cyst causing partial upper airway obstruction in a cat.Journal of Feline Medicine and Surgery Open Reports. 2022; 8(2):20551169221122853. doi: 10.1177/20551169221122853.

Liptak JM, Canfield PJ and Hunt GB. Dermoid cyst in the tongue of a dog.Australian Veterinary Journal. 2000; 78(3):160-161. doi: 10.1111/j.1751-0813.2000.tb10583.x.

Mason BJE. Veterinary Record. 1974; 95:226.

Nishida H, Kakimoto R, Noguchi S, Kanegi R, Shimamura S, Tanaka T, Fumimoto T, Nishibata K, Fujiwara H and Akiyoshi H. A feline spinal dermoid cyst treated with surgical intervention.The Journal of Veterinary Medical Science. 2024; 86(1):116-119. doi: 10.1292/jvms.23-0370.

Purohit NR, Chouhan DS, Dudi PR and Vyas UK. Dermoid cysts in camels.British Veterinary Journal. 1989; 145(1):89-90. doi: 10.1016/0007-1935(89)90015-8.

Ramadan RO. Surgery and Radiology of the Dromedary Camel. Ist. Ed. Aljawad Printing Press, Kingdom of Saudi Arabia. 1994.

Rochat MC, Campbell GA and Panciera RJ. Dermoid cysts in cats: two cases and a review of the literature. Journal of Veterinary Diagnostic Investigation. 1996; 8:505-507. doi: 10.1177/104063879600800423.

Saberi M, Azari O, Kheirandish R, Rasouli R, Aghazamani M and Mohebbi E. Intestinal dermoid cyst in a German shepherd dog. Journal ofthe South African Veterinary Association. 2013; 84(1):E1-3. doi: 10.4102/jsava.v84i1.911.

Sato R, Sonoda M, Matsuo R, Takada R, Kanda I, Satoh H, Fuke N, Yamada K and Hirai T. Surgical management of a dermoid cyst with mandibular gland tissue in a Japanese Black calf. The Journal of Veterinary Medical Science. 2023; 85(10):1110-1115. doi: 10.1292/jvms.23-0248.

Steinmetz A, Locher L, Delling U,Ionita J, Ludewig E, Oechtering G and Wittek T. Surgical removal of a dermoid cyst from the bony part of the nasolacrimal duct in a Scottish highland cattle heifer.Veterinary Ophthalmology. 2009; 12(4):259-262. doi: 10.1111/j.1463-5224.2009.00704.x.

Targett MP, McInnes E, Dennis R. Magnetic resonance imaging of a medullary dermoid cyst with secondary hydrocephalus in a dog. Veterinary Radiology and Ultrasound. 1999; 40(1):23-26. doi: 10.1111/j.1740-8261.1999.tb01834.x.

Tolbert K, Brown HM, Rakich PM, Radlinsky MA and Ward CR. Dermoid cysts presenting as enlarged thyroid glands in a cat.Journal of Feline Medicine and Surgery. 2009; 11(8):717-719. doi: 10.1016/j.jfms.2009.02.005.

Tshamala M and Moens Y. True dermoid cyst in a Rhodesian ridgeback.Journal of Small Animal Practice. 2000; 41(8):352-353. doi: 10.1111/j.1748-5827.2000.tb03217.x.

DOI : 10.5958/2277-8934.2024.00017.1 *Vol 31 No 1, p 95-98*

STANDARDISATION OF SMARTPHONE FUNDUS IMAGING IN DROMEDARY CAMELS (*Camelus dromedarius*)

Bharat Bandhu, S.K. Jhirwal, Mohan Lal Sharma, Sonu Meena and P. Bishnoi

Department of Veterinary Surgery and Radiology, College of Veterinary and Animal Science, Rajasthan University of Veterinary and Animal Sciences, Bikaner- 334 001, Rajasthan, India

ABSTRACT

The present study was done to standardise the technique of cost-effective fundus imaging in camels using a smartphone fundus imaging assembly made from locally available materials such as PVC pipe, sand paper, glue, electrical insulation tape, smartphone with it's back cover and 20 D condensing lens. The camels were examined in sternal and lateral recumbency. The fundus images were recorded in continuous video mode and later on screenshot of desired images were taken from videos. The camels were more convenient in sternal recumbency as compared to lateral. The assembly was held perpendicular to the cornea. During examination, continuous eye globe movement and nictitating membrane covering cornea and sometimes damaged part of pupillary ruff were major constraints. The technique was cost effective, transportable and good quality fundus images were obtained.

Key words: Camel, funduscopy, fundus imaging, smartphone

Fundus photography is a key component of ophthalmology. High-quality fundus images need the use of appropriate optics and illumination. Smartphones are increasingly being used as clinical imaging devices in ophthalmology due to their growing availability and quick advancements in image capture and sharing technologies (Khanamiri *et al,* 2017 and Iqbal, 2021). A commercial fundus camera is expensive (Haddock *et al,* 2013). The images obtained by smartphone ophthalmoscopy are inferior in quality than those obtained by fundus cameras, yet they have great diagnostic significance (Sirin, 2020). The benefits of smartphone fundoscopy include wireless network access, low cost, long battery life, and easy transportability (Kanemaki *et al,* 2016; Haddock, 2018, and Yadav *et al,* 2023). The use of smartphones in diagnostic ophthalmology is growing these days because they make it easier to obtain feasible, high-quality retinal images at the field level. Artificial intelligence was used to detect automated diabetic retinopathy through smartphone-based fundus photography (Rajalakshmi *et al,* 2018). The present study was done to standardise the technique of cost-effective fundus imaging in camels using a Smartphone fundus imaging assembly made from locally available materials.

Materials and Methods

The present study was done in both the eyes (n=78) of 39 dromedary camels of different breeds. The smartphone fundus imaging assembly used was a modified version used previously by Raju *et al* (2016). The cost-effective fundus imaging assembly was made with locally available materials. The PVC pipe as an optical tube was aligned centrally at the camera hole of the smartphone adhered with glue. A piece of sandpaper was rolled and pasted inside the PVC pipe. At the other end of the optical tube, 20D condensing lens was fixed with electrical insulation tape (Fig 3). After smartphone positioned into the back cover, device was ready for fundus imaging. The fundus imaging was done in a semi dark room after dilation of pupil with 0.5% tropicamide, 20-30 min prior to examination.

Positioning and Fundus imaging

The camels were restrained either in sternal (Fig 1) or lateral recumbency (Fig 2). The smartphone side of the attachment was held with one hand while 20D lens rested on thumb of other hand and index or middle finger held the eyelid open, lens was held 3-5 cm away from cornea. The fundus images were taken in continuous video mode with the flashlight on, and then screenshots of the desired fundus images were

SEND REPRINT REQUEST TO BHARAT BANDHU email: bbandhu1997@gmail.com

retrieved from the video. The smartphone's flashlight illumination level was kept mild to maximum and the assembly was moved forward and backward to focus film distance for clear fundus images on the smartphone's display screen. Smartphone-based assembly was focused at various points on the cornea to obtain images of the central and peripheral retina. The optical tube attached with smart phone helped in alignment of phone and 20D condensing lens with respect to the eye, and the assembly was found satisfactory for fundus imaging. The sand paper inside the optical tube prevented scattering of light. The designed assembly was light weight and easy to operate

Results

Positioning of camels and examiner

Thirty two camels were secured in sternal recumbency and seven camels in lateral recumbency.

Fig 1. Fundus image capturing in sternal recumbency using smart phone fundus imaging assembly.

Fig 3. Components of smart phone fundus imaging assembly.

Continuous eye globe movement and covering of the eye globe by the third eyelid, partially or completely and sometimes a damaged floated part of the pupillary ruff produced hindrances in fundus imaging. In general, extending the neck slightly in lateral recumbency and tipping the nose ventrally in relation to the body often helped in the centering of the eyeball and retraction of the third eyelid thus facilitated the fundus visualisation. In younger camels, the fundus examination was difficult as they were quite active and did not follow the commands.

Fundus examination in lateral recumbency was found more satisfactory for aggressive and non cooperative camels. It was more convenient for the examiner in sitting position on suitable height stool when the camel was in sternal recumbency as compared to lateral recumbency. Images of the central

Fig 2. Fundus image capturing in lateral recumbency using smart phone fundus imaging assembly.

and peripheral retina were obtained satisfactorily by focusing the assembly at different corneal areas. Two small white dots were visible in the visual field of each fundus image. A few instances of corneal dryness were noted which might have been avoided by placing cotton over the eye and soaking it in a normal saline solution.

Normal appearance of camel fundus

The normal funduscopic appearance varied greatly between individual camels and among breeds. The created image was 3 to 4 times magnified and inverted. There was no clear differentiation between tapetum and non tapetum. Camel fundus showed high pigmentation area in the dorsal part, and a non pigmentation area in the ventral part. Position of optic

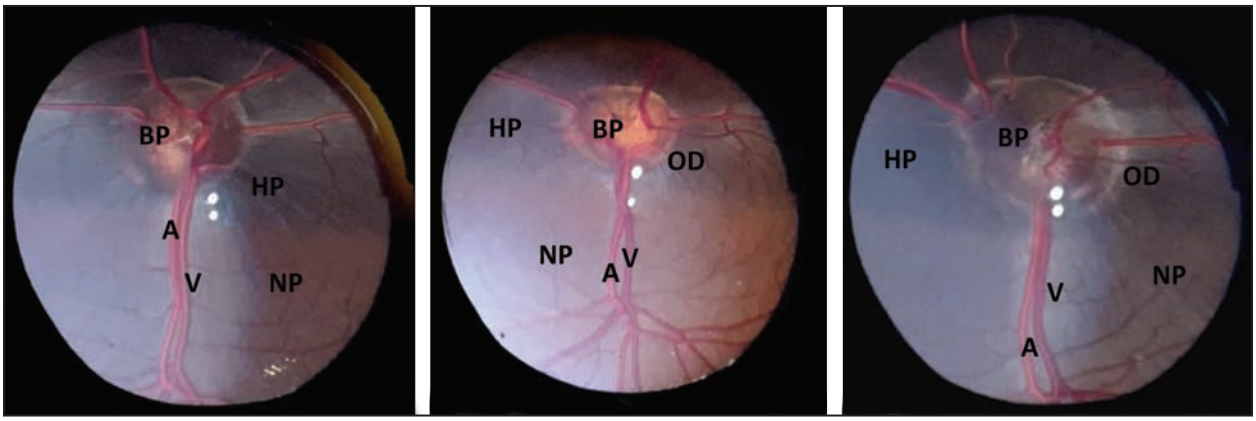


Fig 4. Fundus images showing high pigmentation, non pigmentation area, optic disc and retinal vessels. *HP-High pigmentation area, NP- Non pigmentation area, OD- Optic disc, BP- Bergmeister's papilla, A-Artery, V- Vein.

disc varied and retinal vessels emerged from optic disc towards retinal periphery (Fig 4).

Discussion

The design of smartphone fundus assembly in the present study was modified from Raju *et al* (2016) and Yadav *et al* (2023). In their study, the length of optical tube was 17 cm; however, in present study good quality fundus images were obtained with 26 cm optical tube length which may be attributed to the anatomical variations in the eye of human beings, dog and camel. The principle of smartphone fundoscopy in the present study and the inverted images obtained is based on the principle of indirect ophthalmoscopy in which the examiner's eye is replaced by smartphone's display screen, as stated earlier (Yadav *et al*, 2023).

Fundoscopy in a semi dark space resulted in reduced distracting highlights on the cornea (Yadav *et al*, 2023). When the light level was kept medium to maximum and the assembly was held perpendicular to the cornea, good quality fundus images were obtained. To obtain images of peripheral retina the assembly was focused at various positions of cornea as suggested by Shanmugan *et al* (2014) and Yadav *et al* (2023). In the present study, fundus imaging was done through smartphone camera application and the images were cropped with the smartphone integrated application suggested by Kanika *et al* (2023). However, Haddock *et al* (2013) employed the program Filmic Pro to have more control over camera settings while imaging, including exposure, focus, and lighting level. Filmic Pro or any other external camera application was not required for present study because the built-in camera application provided satisfactory control the focus and illumination level to obtain high quality fundus image.

In the present study, diagnostic quality fundus images were obtained using the smartphone fundus imaging assembly showing a high pigmented and non pigmented area in the fundus which was in agreement with Sini (2015) and Kelawala *et al* (2016). The smartphone fundus imaging was affordable, applicable in telemedicine, and transportable. It provided good quality fundus images, which might further be improved through latest generation of smartphone cameras with high resolution and greater image stabilisation.

Conflicts of Interest

The authors declare no conflict of interest.

References

Haddock LJ, Kim DY and Mukai S. Simple, inexpensive technique for high-quality smartphone fundus photography in human and animal eyes. Journal of Ophthalmology. 2013: 518479.

Iqbal U. Smartphone fundus photography: a narrative review. International Journal of Retina and Vitreous. 2021; 7:44. https://doi.org/10.1186/s40942-021-00313-9

Kelawala DN, Patil DB, Parikh PV, Sini KR, Parulekar EA, Amin NR and Rajput PK. Normal ocular ultrasonographic biometry and fundus imaging of Indian camel (*Camelus dromedarius*). Journal of Camel Practice and Research. 2016; 22(2):181-185.

Kanemaki N, Inaniwa M, Terakado K, Kawarai S and Ichikawa Y. Fundus photography with a smartphone in indirect ophthalmoscopy in dogs and cats. Veterinary Ophthalmology. 2016; 20(3):280-284.

Khanamiri HN, Nakatsuka A and El-Annan J. Smartphone fundus photography. Journal of Visualised Experiments. 2017; 125:e55958.

Rajalakshmi R, Subashini R, Anjana RM and Mohan V. Automated diabetic retinopathy detection in smartphone-based fundus photography using artificial intelligence. Eye. 2018; 32(6):1138-44

Raju B, Raju NSD, Akkara JD and Pathengay A. Do it yourself smartphone fundus camera DIYret CAM. Indian Journal of Ophthalmology. 2016; 64:663.

Shanmugam MP, Mishra DK, Madhukumar R, Ramanjulu R, Reddy SY and Rodrigues G. Fundus imaging with a mobile phone: a review of techniques. Journal of Ophthalmology. 2014; 62:960-962.

Sini KR. Clinical studies on ocular fundoscopy in animals. M.V.Sc. thesis, Anand Agricultural University, Anand, Gujarat. 2015.

Sirin OS. Evaluation of fundus examination of hunting dogs' eyes using a smartphone-based camera. Harran Univ. Veteriner Fakultesi Dergisi. 2020; 9:183-188.

Yadav K, Jhirwal SK and Mishra Saloni. Standardisation of smartphone assembly for fundus imaging in dogs. Indian Journal of Veterinary Surgery. 2023; 44(1):59-60.

News

SYMPOSIUM, STAKEHOLDERS MEETING AND VISIT

Event 1: Participation in **North-East Woolen Expo** held in Guwahati, Assam, from 03 to 09 February 2024 for the promotion of camel fiber processing and marketing.

Event 2: Collaborated in ***Maru Manthan*- 2024,** held in Jaisalmer, Rajasthan on 9-10 February 2024. This event highlights the need to conserve critical desert ecosystems, the pastoral way of living and issues such as livelihood resilience, and sustainability, among the diverse communities and other actors present. This programme aimed to demonstrate Pastoral Production Systems, Show caseinnovations for desert communities, celebratethed the International Year of Camelids, and promoted the networking between individuals and organisations to combine action for a comprehensive desert bioregion agenda.

Event 3: An exposure visit of seven-member team from the North American Camel Ranch Owners Association of America at NRCC on 18-02-2024.

Event 4: AMUL-NRCC Symposium and stakeholders meeting took place along with visit to camel milk collection centre at Ghadsisha village, survey on Kacchiand Kharai camel breeding track, collection of plant and milk samples from the study area, visit Sarhad Dairy and its feed plant in Lakhond during 9 to 10 March 2024.

Event 5: Brainstorming Session on "Unravelling the Rumen Microbiome for Sustainable Ruminant Production: Past, Present and Future" on 12.03.2024. Dr. A. Sahoo (Director, NRCC), Dr N V Patil (Vice Chancellor, MAFSU, Nagpur), Dr. A. K. Puniya (Pr Scientist, NDRI) and Dr. C.G. Joshi (Director, GBRC) and many other prominent scientists attended the event.

Event 6: National Symposium cum Stakeholders Meet on "Importance, Innovation, Improvement in Processing of Non-Bovine Animal Produce for Successful Entrepreneurship" was organised at NRCC, Bikaner during 14 to 15 March 2024. The chief guest of the closing ceremony of the seminar was Prof. Manoj Dixit (Vice Chancellor, Maharaja Ganga Singh University; Bikaner).

INSTRUCTIONS TO CONTRIBUTORS

(Effective from the year 2024)

(Journal of Camel Practice and Research - triannual -April, August and December issues every year)

The Journal of Camel Practice and Research (JCPR) is a triannual journal (April, August and December issues) published in the English language by the Camel Publishing House, 67, Gandhi Nagar West, Near Lalgarh Palace, Bikaner, 334 001 (India). It is in offset print size of 20.5x27.5 cm in two columns with a print area of 17x22 cm. It will be known as **Journal of Camel Practice and Research** with **Volume number** on yearly basis and **Number** on issues per volume basis (in exceptional cases there can be more than three issues in a volume). The editorial policies of JCPR are established by the editor-in-chief and is detailed in this section. Views expressed in papers published in JCPR represent the opinions of the author(s) and do not necessarily reflect the official policy of the author's affiliated institution, or the editor-in-chief.

Nature of coverage: This journal is dedicated to disseminate scientific information about new and old world camelids in form of **Original research** articles in camel science, health, husbandry, pastoralism, sports, specific behaviour, history and socio-economics. **Reports** on unusual clinical case(s) or unreported management of clinical case(s) are also published. Review articles will be accepted on invitation only. **Book review** directly or indirectly related to camels will be reviewed by subject-matter specialists and included if sent to the journal for this purpose. The Journal of Camel Practice and Research will occasionally contain an **invited editorial** commenting on the current research and papers in the issue.

Retraction guidelines (As per the formal COPE policy)

Editor in Chief of JCPR would consider retracting a publication, if: • They have clear evidence that the findings are unreliable, either as a result of major error (eg, miscalculation or experimental error), or as a result of fabrication (eg, of data) or falsification (eg, image manipulation) • It constitutes plagiarism • The findings have previously been published elsewhere without proper attribution to previous sources or disclosure to the editor, permission to republish, or justification (i.e., cases of redundant publication) • It contains material or data without authorisation for use • Copyright has been infringed or there is some other serious legal issue (eg, libel, privacy) • It reports unethical research • It has been published solely on the basis of a compromised or manipulated peer review process • The author(s) failed to disclose a major competing interest (aka, conflict of interest) that, in the view of the editor, would have unduly affected interpretations of the work or recommendations by editors and peer reviewers.

Publication Ethics and Malpractice Statement

JCPR is a peer-reviewed journal and ensures the highest standards of publication ethics. All parties involved in the act of publishing process (editors, authors, reviewers and the publisher) have to agree upon standards of ethical behaviour. The accepted principles of Publication Ethics and Publication Malpractice Statement based on the Code of Conduct and Best Practice Guidelines for Journal Editors of the Committee on Publication Ethics – COPE (available at http://publicationethics.org/) are followed.

Submission of manuscript: Manuscripts should be submitted in word files to **Dr. Tarun Kumar Gahlot,** Editor, Journal of Camel Practice and Research at tkcamelvet@yahoo.com or editorjcpr@camelsandcamelids.com by online submission portals available at www.indianjournals.com or www.camelsandcamelids.com. The figures can be submitted preferably as a high pixel JPEG or other format. The manuscript should be accompanied by a covering note and author consent letter and ethical statement declaration from the author responsible for correspondence. It should also contain a statement that manuscript has been seen and approved by all co-authors. Editor and members of the editorial board are not responsible for the opinions expressed by authors and reserves the right to reject any material or introduce editorial changes. Material will be accepted for publication on the understanding that it has not been published in any other form and is not being considered elsewhere. Any material once accepted for publication may not be republished in any form without prior permission of the author. **Single blind peer review policy** is used for the manuscripts submitted and the quality standards are maintained by the JCPR editorial board and by authors who submit manuscripts for publication. A preprint PDF is provided to the author in correspondence for verification of contents and corrections, if any.

Ethical declarations in research form is an important step while submitting a manuscript to the Journal of Camel Practice and Research (JCPR). Author has to look into several questions and statements before submission. These are listed below:

Pre-submission considerations for authors

- Manuscript should have been read and approved by all the authors. All the authors mentioned in the manuscript should have agreed for authorship and it's order. An author consent letter, duly signed should accompany the manuscript as per the given format (Author in correspondence can do it). (The authorship criteria should be based on the ICMJE guidelines.)
- Full names, institutional affiliations, highest degree obtained by the authors, e-mail address (in some cases, ORCiD ID and social media handles - Facebook, Twitter, or LinkedIn) need to be clearly mentioned on the title page.
- The corresponding author, who takes full ownership for all the communication related to the manuscript, should be designated and his/her detailed institutional affiliation (including the postal address, telephone number, fax number, and e-mail address) should be provided.
- In the research papers, JCPR expects a guarantor (who could be a senior research scientist or one of the author), he/she may be responsible for the integrity of the manuscript (including ethics, data handling, reporting of results, and study conduct), would communicate with the journal if any technical clarifications related to the manuscript are required, and would handle similar responsibilities.

All the authors need to agree on the name(s) included in the Acknowledgement section.

Manuscript submission related declarations: JCPR expects authors to declare the following:

- The manuscript in part or in full has **not been submitted or published anywhere**. In other words, the authors

should ensure that the manuscript is not a duplicate publication.

- The manuscript **will not be submitted elsewhere** until the editorial process is completed.
- If any part of the manuscript contains previously published content (figures/tables), authors should submit a **statement of permission to reproduce the material** signed by the author(s) and publishers concerned.
- When submitting material related to commercial products, it may, in some circumstances, be appropriate for the author to forward a copy of the contribution to the manufacturers before publication. This is to verify the correctness of the contents of the section in the manuscript that describes the new device/product.
- Authors should **declare any previous or pending publication** of the manuscript's content in any conference proceedings, letters to journals and brief communications, or as pre-prints on repositories.
- Authors should ensure that if the current study's Abstract has been published in any conferences, it should not be under a **copyright protection** from the publishers. Necessary permission should be sought for re-using the material.
- In case the manuscript is a secondary publication i.e. it is a subsequent republication that will be published in two or more journals (in the same or another language), the authors should explicitly declare this. Moreover, they should **obtain mutual consent of the journal editors** and follow the stipulated guidelines.
- If the manuscript is based on a dataset that has been the basis of another manuscript, authors should **maintain transparency** in such cases and should declare that by an appropriate reference.
- If there is a data set associated with the manuscript, provide information about where the data supporting the results or analyses presented in the paper can be accessed. Where applicable, this should include the hyperlink to publicly archived datasets, DOI, or other persistent identifier associated with the data set(s).

Statements of ethical approval for studies involving animals

If your study involves animals, and also if your manuscript includes case reports/case series, you need to provide the following:

- Authors must provide the **name of the ethical approval committee/Institutional Review Board** they have obtained consent from along with approval number/ID.
- Authors must state that **written informed consent was obtained** from the owners of the animals or head of the veterinary institutes where the research was carried out.

Declarations specific to article types

We have looked at the declarations related to manuscript submission and when your study involves human (for example-feeding camel milk to the diabetic human patients or autistic patients) or animal subjects. Let us now turn to specific article types and the declarations you need to prepare when submitting them.

1. **Clinical trials and research papers:** All clinical trials and planned research should be approved by the institutional ethics committee and should also be approved through an appropriate research committee of the institute (It should be depicted in the acknowledgement section).
2. **Reviews:** Reviews do not need any ethical approvals or informed consent. However, JCPR expects that the review should not be older than 4 decades.
3. **Short Communications or Case Reports:** These are rare clinical reports or new diagnoses or a new technique (pilot trials), usually published with or without abstract and keywords. These article types do not exceed 2-3 pages of the journal.

Other important declarations related to funding, conflicts of interest, and more

Apart from the declarations we have discussed, there are others that authors need to consider. Let us take a look at them:

1. **Describing new taxa:** Authors must provide relevant documents and unique digital identifier for manuscripts that describe new taxa or species. They should also declare that the relevant guidelines have been followed for algae, fungi and plants, zoological taxa, bacteria, and viruses. Registration numbers for the new species (for e.g. from **MycoBank** for fungi or **ZooBank** for zoological species) should be stated in the manuscript. New virus names should be sent to the relevant study groups for consideration before publication in a journal.
2. **Authors' contribution**: The individual contributions of authors to the research work and writing of the manuscript should be specified in this section; for example, who conceived the study design, who did the data acquisition, who performed the experiments, who did the data analysis, who wrote the manuscript, etc. Authors should check journal-specific guidelines to declare the authors' contribution.
3. **Acknowledgements:** Anyone who does not meet the authorship criteria, such as people who provided technical help, institutional/department head who provided general support, or scientific writers who assisted with the preparation of the manuscript content, should be acknowledged. Even if the authors have no one to acknowledge, usually JCPR expects authors to include this section in the manuscript and write "Not applicable."
4. **Funding:** All sources of funding for the research work and their role (if at all) in the design of the study and collection, analysis, interpretation of data, and in writing the manuscript should be declared. Provide the name(s) of the funding agency/agencies along with the grant number(s). If the study did not receive any funding, report the same.
5. **Competing interests/conflict of interest:** All financial and non-financial competing interests must be declared by the authors. Non-financial competing interests include a declaration of political, personal, religious, ideological, academic, and intellectual competing interests. Authors from pharmaceutical companies, or other commercial organisations that sponsor clinical trials, should declare these as competing interests on submission.

Authors should declare any personal conflict of interest including any association with consultancies; employment details; participation in advocacy groups; stock or share ownership, and any financial details with regard to grants; fees; honoraria, reimbursements royalties, and any registered patents. They should also declare any institutional conflict of interest, i.e. if their employer has any financial interest in or is in conflict with the subject matter or materials discussed in

the manuscript. If there is no disclosure, add the following statement: "No potential conflict of interest was reported by the authors."

It is mandatory and important that the authors declare all the above-mentioned statements to avoid un-submission of the manuscript. These declarations ensure ethical publication publication of the manuscript. JCPR expects from all the authors of manuscripts to read these practices involving transparency and integrity in the guidelines from the webpage of www.camelsandcamelids.com in the Instructions to Contributors section.

Initial Checks

The JCPR staff and in-house editorial team perform an initial quality check to identify potential issues such as:

- Competing interests
- Compliance with editorial policies and ethical standards
- Financial disclosures
- Data availability

Submissions may be returned to authors for changes or clarifications at this stage.

Editorial Review

After completing internal checks, each new submission is assigned to an Academic Editor (Usually Editor in Chief) with relevant subject matter expert. The editor reviews the manuscript against our publication criteria and determines whether reviews from additional experts are required to evaluate the manuscript. The Editor in Chief decides about further handling of the manuscript by usually a member of the Editorial Board of JCPR, but occasionally a Guest Editor is invited to serve instead.

Peer Review

The Editor in Chief selects reviewers, whether internal or external, based on expertise, publication history, and past reviews, and invites them to provide feedback on the manuscript. After agreeing to review, external peer reviewers typically have 10 days to submit their review. The journal office will follow up with late reviewers and keep you informed if there are any delays. **JCPR uses single-blind peer review policy**. Reviewers remain anonymous in our submission system.

Editorial Decisions

The handling Academic Editor (Editor in Chief) or member of the editorial board makes the final decision on each manuscript. The time to render a first decision usually takes 2-4 weeks, but times vary depending on how long it takes for the editor to receive and assess reviews.

The Editor in Chief considers reviewer feedback and their own evaluation of the manuscript in order to reach a decision. The following decision types are available:

- Reject
- Major revision
- Minor revision
- Accept

Decisions are communicated to the corresponding author in a formal letter, along with reviewer feedback and any other requirements from the journal office.

Revisions

If the editor feels that your manuscript has the potential to be published, but requires changes, you'll be invited to revise it. Usually authors are asked to resubmit the revised manuscript for both a major or a minor revision with in 4 weeks.

In most cases, the revised manuscript is re-assigned to the original referee. The Editor in Chief may make a new decision based on their own assessment of the revised manuscript and your response to reviewers, or request additional input from external peer reviewers.

Accepted Manuscripts

JCPR uses two levels of accept decision. When the handling editor is satisfied with the scientific aspects of the manuscript a provisional acceptance decision is communicated, pending final checks for formatting and technical requirements. Once the final requirements are fulfilled, the journal office will send a formal acceptance and the manuscript will move on to production.

Preparation of the manuscript: Manuscript should be typed in Book Antiqua font size 12 using British English, spellings and generic names of drugs. International Code of Zoological Nomenclature, Nomina Anatomica Veterinaria, International Code of Nomenclature of Bacteria, International Code of Botanical Nomenclature and International Standards should be strictly followed. All terms should be identified by their scientific names and for easy comprehension common terms/names can be used. Population data and geographical distribution of camelids should invariably be avoided in introduction, unless it is warranted. Kindly remain restricted to the relevant subject matter of given title of manuscript only. The review of literature should be up to the submission year of manuscript. Kindly check every reference for its accuracy from the relevant book, journal or through google.

Each manuscript should have the following sections:

Title page: This page should contain title of the article, name of the department/institution where work has been done, present postal address of each author and name of author with email to whom reprint request should be addressed.

Running title should be short, succinct title with not more than 45 keystrokes (characters plus spaces) in length. A title should have the first word and proper nouns capitalised. Species of subject is encouraged. The title should be unique. All authors should have preferably full names (given name, middle initial, family name). Institutions of the authors with location should be denoted with either symbols (*, †, ‡, §, #, ||, and ¶) or Roman numerals behind the author's last name. Affiliation should also include department, city, state, country, and postal code.

Following is the example:

Example:

PROTEOMIC CHARACTERISATION OF SERUM DURING THE BREEDING CYCLE IN MALE BACTRIAN CAMELS

Le Hai[1], Rendalai Si[2], Fu-Cheng Guo[1], Jing HeI, Li Yi[1], Liang Ming[1], Jun-Wen Zhou[3], La Ba[3], Rigetu Zhao[3] and Rimutu Ji[1,2]

[1]Key Laboratory of Dairy Biotechnology and Bioengineering, Ministry of Education, Inner Mongolia Agricultural University, Hohhot, Inner Mongolia, China

[2]Inner Mongolia Institute of Camel Research, Badanjiran, Inner Mongolia, China

[3]Alxa League Institute of Animal Husbandry, Alxa, Inner Mongolia, China

SEND REPRINT REQUEST TO RIMUTU JI email: yeluotuo1999@vip.163.com

Abstract and Key words: A single paragraph of no more than 2,500 keystrokes (characters plus spaces) that summarises the results in an understandable form using statistical evidence (P-values). Abbreviations are defined at first use in the ABSTRACT and again in the body of the manuscript. List up to 6 key words in alphabetical order and separated by a comma. Capitalise only proper nouns. Do not use abbreviations. Place the key words at the end of the Abstract.

Text: The proper text of the paper should commence after key words. The text should be divided into sections with headings, introduction, materials and methods, results, discussion, tables/illustrations and references.

Introduction: The logic of the introduction is to introduce the specificity and relevance of the topic to the readers. It should include the objective of the work in brief and most important related reference(s). The contents of the introduction should be lucid showing a clear justification for conducting the research with a stated hypothesis and objective(s) is required. The population data of camelids and their importance should be avoided as it is well known and is not relevant to the title in most of the manuscripts. Authors should not write the word, "First report" as later it is found that previous reports exist. The rationale for the experiments should place the work into the context of existing literature. There is NO word limit on the section but brevity is encouraged.

Materials and Methods: Should contain details regarding materials and brief account of procedures used. The manuscript must include a statement of institutional animal care and use or ethical committee, or country-specific equivalent, approval of all animal procedures. This statement should appear as the first item in MATERIALS AND METHODS and should specify which publicly available animal care and use standards were followed. A clear description of all biological, analytical and statistical procedures is required with each section denoted by a short descriptive title (i.e., Animals and sampling, Tests used, Treatment, Experimental design and analysis, etc). Materials used must include the product name and vendor at first mention. When a commercial product is used as part of an experiment, the manufacturer name and location must be given parenthetically and the generic name should be used subsequently. No ™, ®, or © symbols should be used. Sex, breed, age, species are included in the animal descriptions. Provide evidence of assay validation, or suitable published reference, as well as inter/intra-assay CV, as needed. Appropriate statistical methods should be used with experimental unit defined. Numbers of biological and experimental replicates should be stated. State the threshold for significance ($P < 0.05$) and definition of tendency if used. In case reports, the case record sheet should also be included in materials and methods.

Results and Discussion should be presented in logical sequence with implications of findings about other relevant studies. The data or information easily attainable from the tables or graphics need not be repeated in the results. Only important observations need to be summarised. Undue repetition of the text from results to discussion has to be avoided. To preclude it, depending on article, results and discussion can be combined. In discussion only significant results should be discussed. One should not always stick to the term `statistically significant' data rather biological importance or significance of any variation should be given due importance in discussion. The section contains the interpretation of the results. It should be clear and concise, address the biological mechanisms and their significance, and integrate the results into existing literature. The Discussion may offer an interpretation that is consistent with the data. Do not include any reference to tables and figures or include P-values in the Discussion. Authors have the option to create a single RESULTS AND DISCUSSION section.

Tables: Each tables should be typed on separate sheet. Large tables should be avoided and should not exceed one page. Each table should be numbered in Indo-Arabic numerals according to their sequence in the text that refers to it. In the text it should be referred as proper noun e.g., Table 1. The title of the table should be brief and self-explanatory. Footnotes can be included to enhance understanding ability of the contents of the table.

Illustrations and Legends: All illustrations should be submitted about twice the size desired for reproduction that is 17 cm for double column or 8.3 cm for single column. Photographs should be of good quality with adequate contrast and high pixels. All illustrations should be referred as figures in the text and should also be numbered in Indo-Arabic numerals e.g., Fig 1. Legends of all these figures should be typed on a separate sheet. Each legend should be clear, concise and informative. A statement of magnifications or reductions should be given where it is applicable.

Disclosures (Conflict of Interest)

The authors must disclose any actual or potential conflicts of interest that may affect their ability to objectively present or review research or data. A succinct statement detailing any perceived conflict of interest is required. If none, please indicate as such.

References: Papers in the section must either be published or 'in press'. All references must include the DOI, if available. Authors are encouraged to use the most recent reference style for the Journal of Camel Practice and Research in the reference writing. References should be arranged in alphabetical order. Authors should not modify the title of the references. Mention full name of the journal.

Examples of correct forms of references are given below:

Periodicals: Shawaf T, El Nahas A, Melegi A, Al Bulushi S, Aiyan AA and Eljalli I. Investigation on biochemical parameters of cerebrospinal fluid in camels with neurological disorders. Journal of Camel Practice and Research. 2020; 27(2):165-171.

Wilson R Trevor. The one-humped camel in Eritrea and Ethiopia: a critical review of the literature and a bibliography. Journal of Camel Practice and Research. 2020; 27(3):229-262.

For edited symposium/congress/proceedings: Abdalla HS. Camel trypanosomiasis in the Sudan. Proceedings of the First International Camel Conference, Dubai (UAE). February 2-6, 1992; pp 401-403.

Books (Personal authors): Faye B and Bengoumi M. Camel Clinical Biochemistry and Haematology: Springer International Publishing. 2018; pp 275-286.

Chapter from multiauthored books: Wernery U, Kinne J and Schuster RK. Unusual arboviruses and other minor viral infections. In: Camelid Infectious Disorders. OIE Book. 2014; pp 319-322.

Thesis: Rathod Avni. Therapeutic studies on sarcopticosis in camels (Camelus dromedarius). Unpublished Masters Thesis (MVSc), Rajasthan Agricultural University, Bikaner, Rajasthan, India. 2006.

Commercial booklets: Anonymous/Name. Conray-Contrast Media. IIIrd Edn., 1967; pp 12-15, May and Baker Ltd., Dagenham, Essex, England.

Magazine articles: Taylor D. The Constipated Camel. Reader's Digest. Indian Edn. RDI Print & Publishing (P) Ltd., Mehra House, 250-C, New Cross Road, Worli, Bombay, India. 1985; 126:60-64

News paper articles: Christina Adams. Camel milk: a miracle cure for children with autism?. Gulf News, Published: April 09. 2014.

Personal communication: Hall LW. Reader in Comparative Anaesthesia, Department of Clinical Veterinary Medicine, Madingley Road, University of Cambridge, Cambridge, CB3 0ES, England. 1995.

Reprints or Publication charges: There is no provision for free reprints. Author or person in correspondence has to pay INR 4500/- (for Indian Citizens only) or US $ 450, in advance to receive a final PDF or for 10 reprints for the year 2024. Publication charges for colour and black and white pictures: Author(s) has to pay publication charges of colour plates in his/her manuscript as per the invoice provided to them. Publication charges would be double if a manuscript is more than 10 printed pages in length. The publication charges can be paid into the bank account of Camel Publishing House (using cheque, demand draft or money transfer method) or through a payment portal given in our website www.camelsandcamelids.com. Author(s) will be sent final pre-published PDF for verification and corrections, if any, along with an invoice and bank account details for making advance payment, before publication of manuscript in JCPR.

Author Consent Letter

{Note: Kindly take print out of the Author Consent letter form, fill, scan and send along with your manuscript. Without Author Consent letter your manuscript will not be considered for publication}

To

Editor in Chief

Journal of Camel Practice and Research

Camel Publishing House

Bikaner

Sub: Submission of manuscript for publication in Journal of Camel Practice and Research reg.

Dear Sir

I hereby submit the manuscript for publication in 'Journal of Camel Practice and Research". I assure that this manuscript has neither been published in any other journal nor submitted for publication in any other journal. I also undertake along with the other authors that present study (on animals, human or laboratory animals, if any) was undertaken after the prior approval of relevant country/ institutional ethical committee. I and on behalf of other co-author(s), I declare "No conflict of interest". I assure that this article do not have any plagiarism. Kindly consider the manuscript for publication in your journal. I abide all rules and regulations of the journal. In future if any litigation arises in this article I will cooperate with the editor to resolve the issue. I shall accept the decision of the editor and that would be final.

Thanking You

SIGNATURE of Corresponding Author

NAME

ADDRESS

Kindly enter the details in the following

Manuscript

TITLE:

SUBJECT:

LABORATORY/RESEARCH CENTRE/INSTITUTE:

Ethical Statement Declaration

Hereby, I /insert author name/ consciously assure that for the manuscript /insert title/ the following is fulfilled:

1) This material is the authors' own original work, which has not been previously published elsewhere.
2) The paper is not currently being considered for publication elsewhere.
3) The paper reflects the authors' own research and analysis in a truthful and complete manner.
4) The paper properly credits the meaningful contributions of co-authors and co-researchers.
5) The results are appropriately placed in the context of prior and existing research.
6) All sources used are properly disclosed (correct citation). Literally copying of text must be indicated as such by using quotation marks and giving proper reference.
7) All authors have been personally and actively involved in substantial work leading to the paper, and will take public responsibility for its content.

The violation of the Ethical Statement rules may result in severe consequences.

To verify originality, your article may be checked by the originality detection software for plagiarism.

I agree with the above statements and declare that this submission follows the policies of Journal of Camel Practice and Research as outlined in the Guide for Authors and in the Ethical Statement.

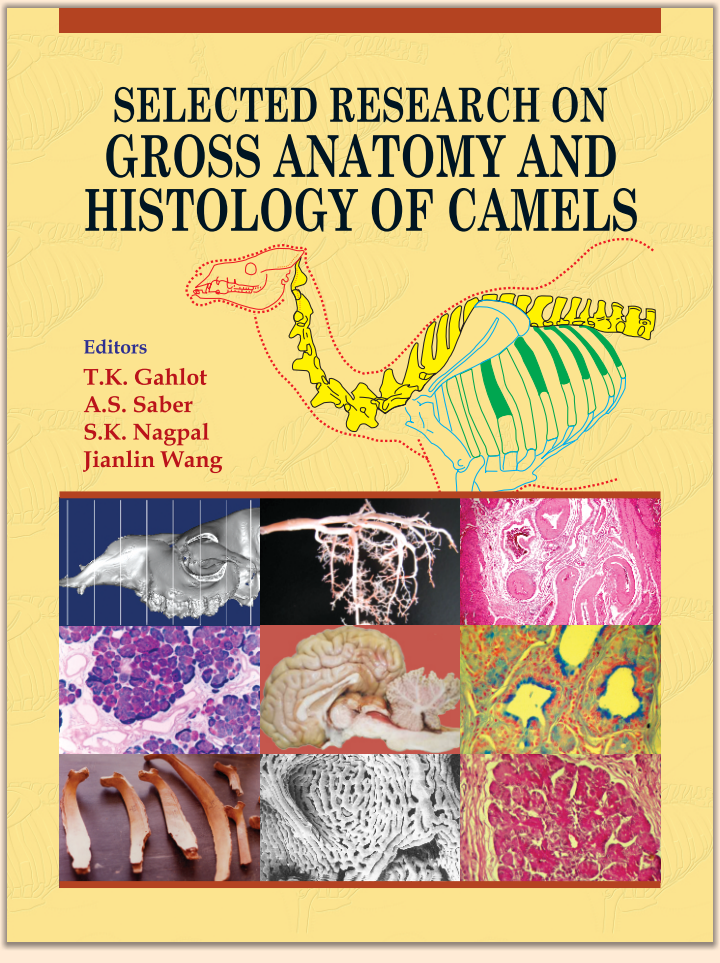
Date:

Corresponding author's signature:

SELECTED RESEARCH ON
GROSS ANATOMY AND HISTOLOGY OF CAMELS

Hard bound, 452 pages, few figures coloured

Selected Research on Gross Anatomy and Histology of Camels is a unique reference book on anatomy of dromedary and bactrian camels. This book contains a first ever wide spectrum of histological description of various organs of camels which is depicted by special stains and scanning electronmicroscopy in addition to the gross anatomy, histochemical and immunohistochemical studies. The book has 92 manuscripts in 9 sections, e.g. radiographic anatomy, anatomy of various systems (skeletal, digestive, respiratory, circulatory, urogenital and nervous), common integument and miscellaneous. These manuscripts were published by 158 authors working in 37 laboratories or colleges or institutions from 14 countries in the Journal of Camel Practice and Research between June 1994 to June 2010. Bactrian camel anatomy research was exclusively contributed by the researchers of China. The countries involved in camel anatomy research were China, Egypt, India, Iran, Saudi Arabia, Iraq, Jordan, Japan, Pakistan, Sweden, United Arab Emirates, United States of America, France and Germany. Camel Publishing House has taken a step forward to compile this knowledge in form of a book and this herculian task was accomplished by its dedicated editors, viz. T.K. Gahlot (India), S.K. Nagpal (India), A.S. Saber (Egypt) and Jianlin Wang (China). This classic reference book will serve as a one stop resource for scientific information on gross anatomy and histology of camels.



Editors:
T.K. Gahlot, A.S. Saber, S.K. Nagpal and Jianlin Wang

Edition: 2011

Publisher: **Camel Publishing House**
67, Gandhi Nagar West,
Near Lalgarh Palace
Bikaner 334001 Rajasthan,
India
email: tkcamelvet@yahoo.com
website: www.camelsandcamelids.com

Price: US $ 375 (Abroad)
INR 7500 (India)

ISBN: 81-903140-1-7