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

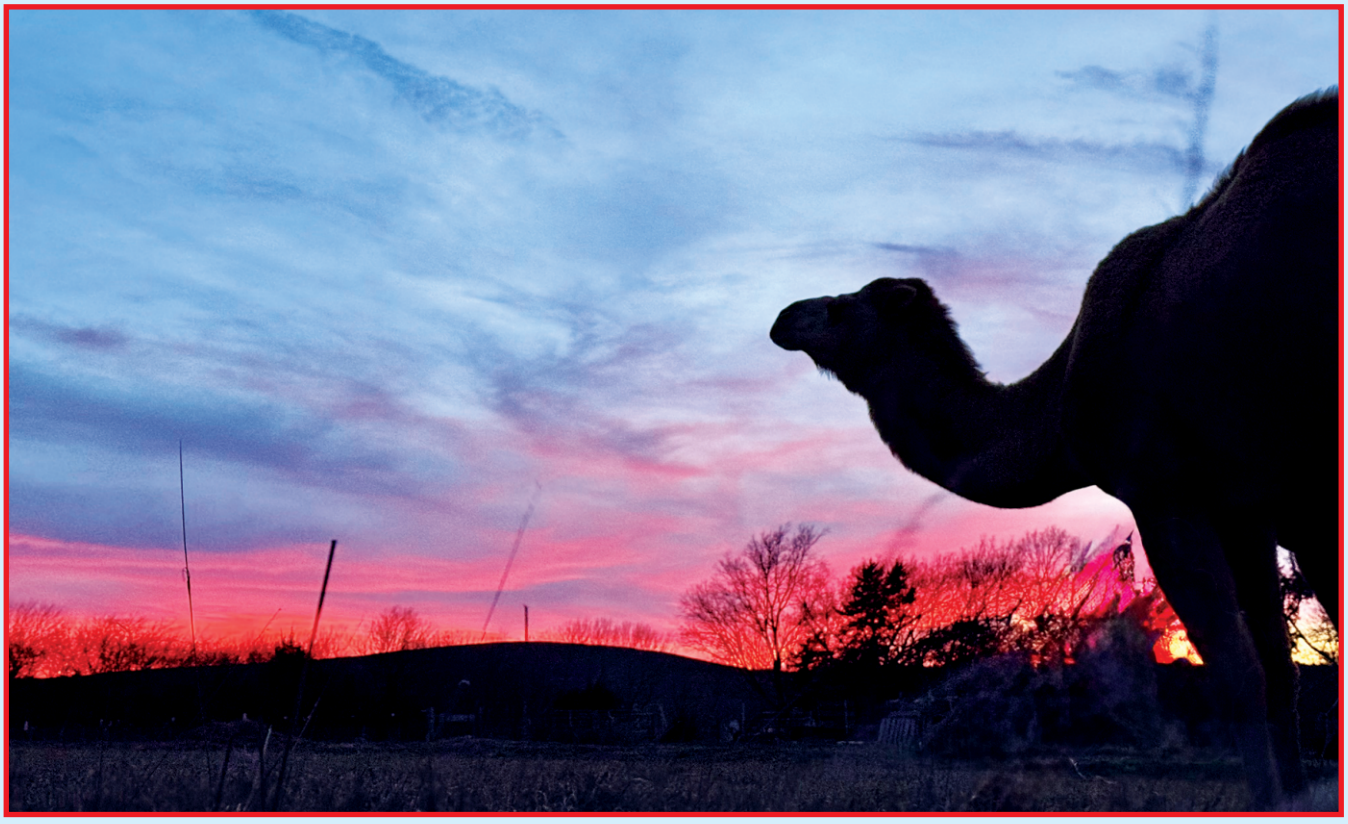
# JOURNAL OF CAMEL PRACTICE AND RESEARCH

www.camelsandcamelids.com • www.indianjournals.com

Volume 33 April 2026 Number 1

## In This issue





# JOURNAL OF CAMEL PRACTICE AND RESEARCH

**EDITOR**

**TARUN KUMAR GAHLOT**

Camel Publishing House

Bikaner - 334001, INDIA

Email : tkcamelvet@yahoo.com

Website : www.camelsandcamelids.com • www.tkgahlotcamelvet.com • www.indianjournals.com



**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 - 2026

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:** A 5-year-old camel named Sadri (named after the town in Rajasthan) as he enjoys the final bits of light of the sunset at Shamrock Farms

**Courtesy:** Valeri Crenshaw

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

# CONTENTS

**Volume 33** **April 2026** **Number 1**

# AN UPDATE OF CAMELOLOGY IN GENOMICS, MOLECULAR EVOLUTION, NABOBODIES, CAMEL MILK AND ASSISTED REPRODUCTIVE BIOTECHNOLOGY

Camel science, often referred to as Camelology, has transitioned from niche natural history observations to a cutting-edge field of biotechnology and medicine. In recent years, particularly leading into 2026, research has shifted from simple "survival studies" to exploring camels as a "livestock of the future" due to their climate resilience and unique molecular biology. Out of four key domains the first relates to genomics and molecular evolution. Scientists have developed high-quality whole-genome drafts for both the dromedary (one-humped) and Bactrian (two-humped) camels. Specific genes (like CYP2J) have been identified that evolved rapidly to help camels manage salt metabolism and prevent dehydration. Genetic markers in camels, including microsatellites (STRs), mitochondrial DNA (mtDNA), and SNPs, are essential for identifying breeds, assessing genetic diversity, and selecting traits like milk production or disease resistance. Key markers commonly used include microsatellite loci such as LCA66, VOLP03, YWLL08, and CVRL01. Second key domain is camel nanobodies, or VHH single-domain antibodies, are a specialised class of antibody fragments (approx. 12–15 kDa) derived from the heavy-chain-only antibodies (HCAbs) found in Camelidae (camels, llamas, alpacas). Their small size, high stability, and ability to bind cryptic epitopes (hidden, recessed areas) have made them a revolutionary tool in biomedical research, diagnostics, and therapy. These "nanobodies" are currently being used to develop new treatments for cancer, rheumatoid arthritis, and viral infections (including COVID-19 and MERS). Their small size allows them to reach targets in the human body that conventional drugs cannot. The third key domain is camel milk which is a functional food. Medical researchers have found its therapeutic properties for diabetes management. Clinical studies have confirmed that camel milk contains insulin-like proteins that do not coagulate in the stomach, allowing them to be absorbed into the bloodstream. It has been shown to reduce the required insulin dose in Type-1 diabetic patients by up to 30%. Additionally the camel milk possess hypoallergenicity property because u nlike cow's milk, camel milk lacks beta-lactoglobulin, making it a safe alternative for children and adults with severe dairy allergies. The fourth key domain is Assisted Reproductive Technologies (ART). New techniques involving specialised "vaginal condoms" and better cooling extenders have made artificial insemination (AI) more viable for breeders. Embryo Transfer has become very popular in camels. Elite racing and milking camels are now frequently used as "genetic donors," with their embryos transferred to surrogate "recipient" camels to speed up the propagation of superior traits.

The Journal of Camel Practice and Research (JCPR) has now entered in the 33rd year of its continuous publication. JCPR is indexed in Scopus under Animal Science & Zoology. The journal is also indexed in CABI databases (important for agriculture & veterinary sciences). It has been submitted to the Web of Science for a consideration. The April 2026 issue has two review papers, i.e. the first one relates to camel production-dynamics and constraints in Morocco and other is on general anaesthesia. It has two important papers from UAE, i.e. correlation of selenium and the electrocardiogram in dromedary and a new concept of bacterial defense mechanism of the pleural lung curtain in dromedary. Scientists have contributed papers from Argentina, Algeria, Australia, Ethiopia, India, Italy, Qatar, Japan, Morocco, Saudi Arabia, Sudan, and UAE.

My greetings of new year 2026 to all the camel scientists and practitioners. I am sure that the journal would continue with your support as a biggest platform of camelid literature at global level.

With my best wishes

(Dr. Tarun Kumar Gahlot)
Editor

DOI : 10.5958/2277-8934.2026.00001.0 *Vol 33 No 1, p 1-9*

# SELENIUM AND THE ELECTROCARDIOGRAM IN THE DROMEDARY CAMEL (*Camelus dromedarius*)

**Howarth FC[1], Tinson A[2], Yasin J[3], Baniyas SM[1], Alderei MH[1], Aldhaheri DH[1], Labata FG[4] and Jacobson M[5]**

[1]Department of Physiology, [3]Department of Internal Medicine,
College of Medicine and Health Sciences, UAE University, Al Ain, UAE
[2]Camel Research Centre, Al Ain, UAE
[4]Integrative Agriculture, College of Agriculture and Veterinary Medicine, UAE University
[5]School of Science and Engineering, University of Northwestern, St. Paul, MN, USA

## ABSTRACT

Selenium (Se) is an essential trace element with well-established roles in antioxidant defense, redox regulation, and cardiovascular function. Both Se deficiency and excess have been associated with myocardial dysfunction and electrocardiographic (ECG) abnormalities in several animal species, yet limited data are available in the dromedary camel (*Camelus dromedarius*). The present study investigated the relationship between Se status and cardiac electrical activity in a cohort of apparently healthy adult female camels. Twenty camels (age 9.8 ± 0.3 years; body mass 406 ± 7 kg) were studied. Se concentrations were measured in hair and blood serum using inductively coupled plasma mass spectrometry. ECG recordings were obtained in a modified base–apex configuration under standardised conditions, and multiple ECG parameters were quantified, including PR, QRS, QT, corrected QT (QTc), ST and RR intervals, heart rate, and short-term heart rate variability. Mean Se concentrations were 0.61 ± 0.05 mg $kg^{-1}$ in hair and 133 ± 10 ng $ml^{-1}$ in serum, values consistent with previously reported reference ranges for camels. ECG analysis demonstrated considerable inter-individual variability in waveform morphology and interval duration, with a mean HR of 54 ± 3 beats $min^{-1}$. Occasional arrhythmias, including premature ventricular contractions and marked bradycardia, were observed in a small number of animals and excluded from summary analysis. Correlation analysis revealed no significant associations between Se concentrations in serum or hair and PR interval, QRS duration, QTc interval, or HR ($|r| < 0.5$ for all comparisons). These findings indicate that, in apparently healthy adult female camels with Se concentrations within physiological range, Se status is not associated with alterations in resting ECG parameters. The results suggest that Se-related electrophysiological effects reported in other species may be context-dependent and become clinically relevant primarily under conditions of Se deficiency, excess, or additional metabolic or oxidative stress.

**Key words:** Camel (*Camelus dromedarius*), Electrocardiogram, Heart, Selenium

Selenium (Se) is an essential trace element that plays a critical role in antioxidant defense, immune function, reproduction, endocrine, neural and cardiovascular systems and metabolic regulation in animals, including the dromedary camel (*Camelus dromedarius*) (Faye and Seboussi, 2009; Fairweather-Tait *et al,* 2011; Rayman, 2012; Kieliszek, 2019; Abdelrahman *et al,* 2022a; Schomburg, 2022). There is a high correlation between serum Se concentration and blood glutathione peroxidase (GSH-Px) (Hamliri *et al,* 1990; Corbera *et al,* 2001; Seboussi *et al,* 2008). As a constituent of selenoproteins, such as GSH-Px, Se protects cells from oxidative damage and maintains tissue integrity (Hamliri *et al,* 1990; Corbera *et al,* 2001; Venardos *et al,* 2004; Seboussi *et al,* 2008). Se deficiency is associated with disorders including white muscle disease, cardiomyopathy, disturbances in cardiac rhythm, impaired fertility and reduced disease resistance (Faye and Bengoumi, 1994; Al-Qarawi *et al,* 2001; El-Khouly *et al,* 2001; Gutierrez *et al,* 2001; Faye and Seboussi, 2009; Seboussi *et al,* 2009a; Seboussi *et al,* 2009b; Fantinato and Binanti, 2015; Özdemir *et al,* 2016; Ali *et al,* 2019; Kieliszek, 2019; Ali *et al,* 2021; Shahin *et al,* 2021; Abdelrahman *et al,* 2022a; Ardahanli and Ozkan, 2022). Long-term Se supplementation, combined with the use of angiotensin-converting enzyme inhibitor and beta blocker therapy, improved the survival of patients with chronic Keshan disease and congestive heart failure (Zhu *et al,* 2019). Dromedary camels, which are uniquely adapted to arid and semi-arid environments, are particularly vulnerable to Se imbalance due to low and variable soil and forage Se content (Abdelrahman *et al,* 2022a; Abdelrahman *et al,* 2022b; Abdelrahman

SEND REPRINT REQUEST TO HOWARTH FC email: chris.howarth@uaeu.ac.ae

*et al,* 2025). Dietary Se supplementation increases the Se concentration in blood and to varying extents in organs including kidney, lung, spleen, liver lung and hair (Seboussi *et al,* 2008; Faye and Seboussi, 2009; Seboussi *et al,* 2010). Excessive intake of Se can cause selenosis and systemic toxicity (Gasmi *et al,* 1997; Faye and Seboussi, 2009; Seboussi *et al,* 2009a). Recent studies in camels have characterised regional variations in Se status, tissue distribution, and physiological responses to deficiency and supplementation, demonstrating both beneficial and dose-dependent toxic effects (Faye and Seboussi, 2009; Seboussi *et al,* 2009a; Abdelrahman *et al,* 2022b; Bataa *et al,* 2022). These findings highlight the importance of optimised Se management to support camel health and productivity.

Se concentrations in camel blood have been reported in many studies with values varying according to age, sex, and study population (Hamliri *et al,* 1990; Zongping, 2003; Faye *et al,* 2005; Barri and Al-Sultan, 2007; Seboussi *et al,* 2010; Acosta-Dacal *et al,* 2025; Meligy *et al,* 2024).

Experimental studies using isolated heart preparations have demonstrated that Se supplementation markedly improves post-ischemic recovery of mechanical performance and reduces lipid peroxidation and metabolic indicators of myocardial damage, underscoring its cardioprotective potential under conditions of acute oxidative stress (Sinci *et al,* 1998). Abnormal electrocardiograms (ECGs) have been reported in rats and lambs fed a low Se diet (Godwin, 1965; Godwin and Fraser, 1966). Ultrastructural defects, hemodynamic alterations and ECG disturbances have been reported in rats fed Se restricted diet (Wildman *et al,* 1994). Se has protective effects against experimentally induced myocardial infarction in rats (Dallak, 2017). Hearts from Se deficient rats were more susceptible to ischemia–reperfusion injury (Venardos *et al,* 2004) and addition of Se to reperfusion solutions improved cardiac functional recovery and decreased postischemic myocardial injury in isolated guinea pig heart (Sinci *et al,* 1998). Sodium selenite causes a contracture state both in Langendorff perfused rat hearts and isolated papillary muscles (Ugur and Turan, 2001). Gender dependent effects of toxic concentrations of sodium selenite on the ECG and left ventricular pressure have been demonstrated in perfused rat heart (Ayaz *et al,* 2007). Neonatal rats fed a Se deficient diet showed a high incidence of ECG abnormalities including sinus arrhythmia and extrasystole and there was also left ventricular hemodynamic dysfunction (Okamoto *et al,* 1999). Studies in non-diabetic hearts have shown that chronic Se administration can alter the kinetics of L-type $Ca^{2+}$ and $K^{+}$ currents, reduce inward rectifier $K^{+}$ current density, and shift myocardial redox balance toward oxidation, changes that may increase susceptibility to electrical instability when Se exposure exceeds physiological requirements (Ayaz *et al,* 2005). Diets deficient in Se and Vitamin E impairs L-type $Ca^{2+}$ current responses to isoproterenol in rat ventricular myocytes as a result of a defect in the β-adrenoceptor-adenylate cyclase pathway (Sayar *et al,* 2000). Notably, Se deficiency alone, in the presence of adequate vitamin E, does not appear to induce significant electrophysiological or mechanical abnormalities in the healthy rat heart, suggesting that the effects of Se are highly context-dependent and become more pronounced under conditions of oxidative or metabolic stress (Ringstad *et al,* 1988). Collectively, these findings highlight Se as a critical yet tightly regulated modulator of cardiac redox state, ionic currents, and calcium homeostasis.

Several studies have reported ECG derived heart rate (HR) measurements in camels, demonstrating considerable variation with age and body size. Braun *et al* (1958) recorded a resting pulse rate of 24-30 beats per minute (bpm) in a 265-kg adult male camel. Age-related changes in HR were described by Pourjafar *et al* (2011), who reported mean HRs of 89 bpm in camels younger than 6 months, 69 bpm in camels aged 7-9 years, and 56 bpm in those aged 13-15 years. Samimi and Sanjarinejad (2021) reported HRs of 80 bpm in 5-year-old male camels, while Howarth *et al* (2025) documented a mean HR of 69 bpm in 9.5-year-old female camels.

The aim of this study was to measure Se concentrations in hair and blood serum, and to measure a range of electrocardiographic parameters in a group of apparently healthy adult female camels, in order to investigate potential associations between Se status and cardiac electrical activity.

## Materials and Methods

Twenty female dromedary camels, aged 9.8±0.3 years and weighing 406.5±6.6 kg, accommodated at the Camel Research Centre, Al Ain were used in this study. All the camels used in this study were apparently healthy. Animals were weighed before measurement of the ECG. Ethical approval for the project was obtained from the UAE University Animal Ethics Committee.

**Measurement of Se in hair and blood:** Hair samples were collected from the withers area of

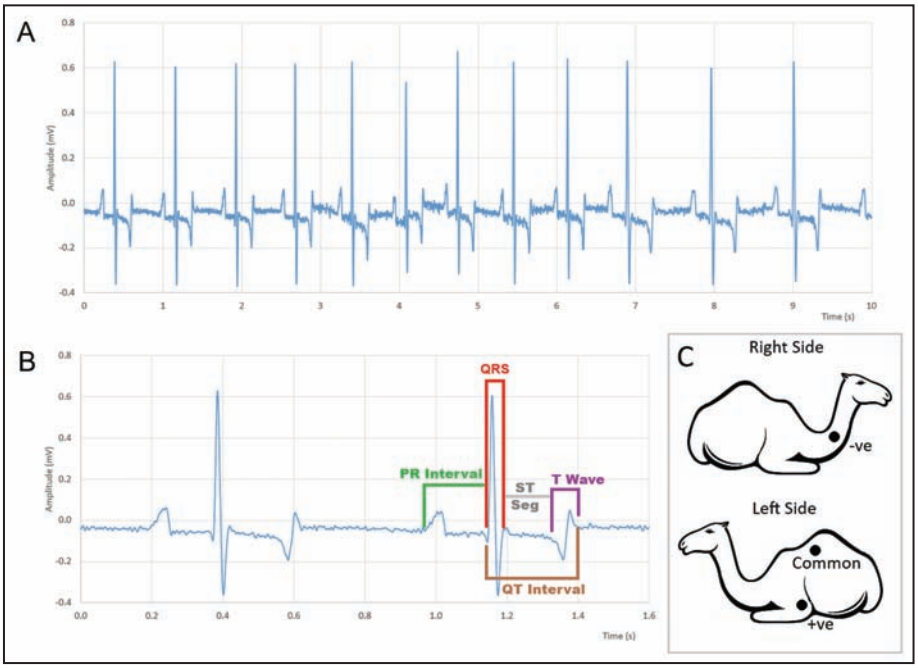



**Fig 1.** Electrocardiographic recording. (A) ECG of camel 2, an adult, 9-year-old female camel displaying positive P Wave with biphasic QRS and T Wave deflections, (B) One cycle on an expanded scale with indicated wavelet intervals. Recordings were made in modified base-apex lead configuration as displayed in (C).

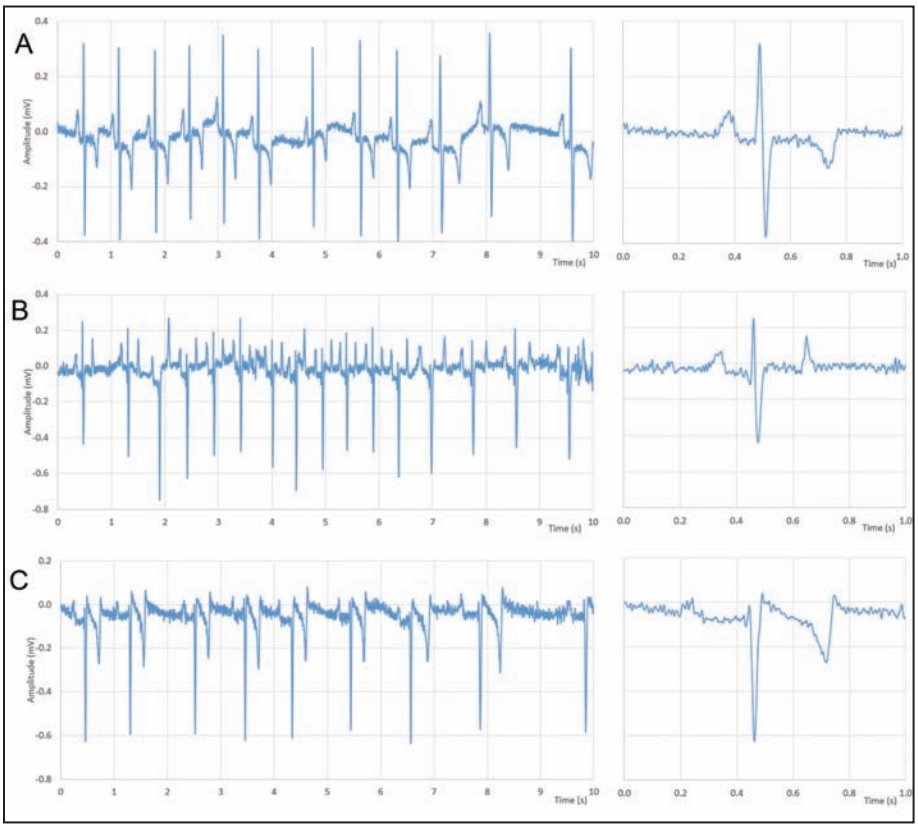



**Fig 2.** Typical ECG traces showing varying configuration of P, QRS and T waves. Sample 10 sec strip on the left and 1 sec expanded scale on the right. (A) P wave +ve, QRS biphasic, T wave -ve, (B) P wave +ve, QRS biphasic, T wave +ve and (C) P wave +ve, QRS -ve, T wave biphasic.

camels, placed in sterile collection tubes, and stored at 4°C. After measuring the ECG a sample of blood was collected from the jugular vein using vacutainer blood collection tubes (Yellow top, BD Vacutainer) for serum analysis. The blood sample tubes were centrifuged at 4000 rpm for 5 min at room temperature (Rotofix 32A, Hettich Zentrifugen). Supernatants were transferred to Eppendorf tubes (Microtubes, Tube-170-C, 1.5 ml, Extragene) and stored at -80°C. Hair samples were washed 3 times with Milli-Q water and placed in an oven at 50°C for 24 hrs to dry thoroughly. Weighed hair samples were digested in 8 ml of nitric acid (Sigma-Aldrich, 30709) and 1 ml hydrochloric acid (Univar, 1367) in a microwave (CEM, Model MARS 6). Serum samples were diluted (25X) with 1% nitric acid (Sigma-Aldrich, 30709) and 0.001 % Triton X (BDH, 30624). Measurement of Se was performed by inductively coupled plasma mass spectrometry (ICPMS, Agilent, 7850). The system was calibrated with a standard calibration solution (Merck, 70350.0100).

**Electrocardiographic recording:** ECG recording was performed according to previously described techniques (Howarth *et al*, 2025). Typical recordings of ECG are shown in Fig 1A and two cycles on an expanded scale are shown in Fig 1B. In brief, camels were seated in a sternal recumbency

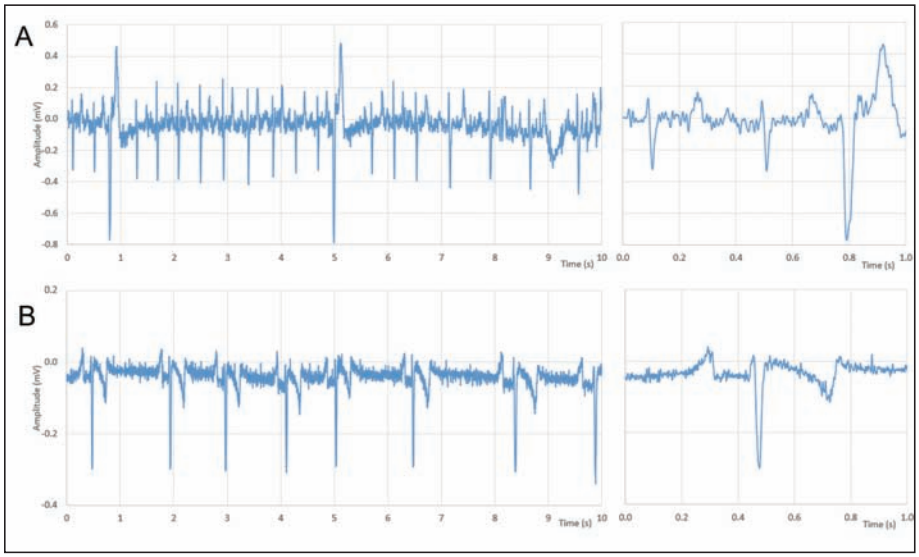



**Fig 3.** Examples of ECG arrythmia. (A) PVC contractions with tachycardia. (B) Varying diastole associated with bradycardia.

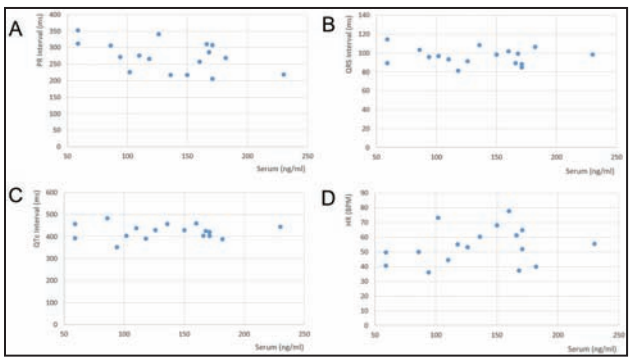



**Fig 4.** Charts displaying no correlation between camel Se measured in serum and PR Interval, QRS Interval, QTc Interval, and HR. (A) PR Interval vs. serum Se, (B) QRS Interval vs. serum Se. (C) QTc Interval vs. serum Se and (D) HR vs. serum Se.

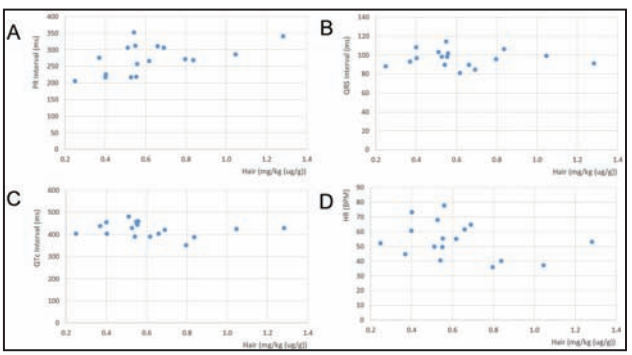



**Fig 5.** Charts displaying no correlation between camel Se measured in hair and PR Interval, QRS Interval, QTc Interval, and HR. (A) PR Interval vs. hair Se, (B) QRS Interval vs. hair Se. (C) QTc Interval vs. hair Se and (D) HR vs. hair Se.

position as shown in Fig 1C. Hair was removed from the electrode locations with an electronic razor followed by a hand razor. The area was cleaned with ethanol. A small bead of electrocardiographic gel (Konix) was placed on each of three disposable electrocardiographic adhesive button electrode pads (Sino-K, X0024ZRZRN). The electrode pads were then attached to the hide. Electrodes were placed in a modified apex-base configuration as shown in Fig 1C. The negative electrode was placed on the right side of the neck, in the jugular groove, about one-third the distance from the mandible to the thoracic inlet (Fig 1C). The positive electrode was placed on the left side of the thorax, just caudal to the olecranon, the point of the elbow, and slightly above the cardiac apex (Fig 1C). The ground electrode was placed on the withers, the highest point of the shoulders (Fig 1C). Electrodes were connected via cables to a PowerLab 26T (ADInstruments, ML856). The PowerLab was connected to a laptop computer. ECG data was acquired at a sampling rate of 2k/sec with LabChart 7 software (v7.3.8, ADInstruments). Data acquisition was continued for a period of three minutes.

The LabChart datafiles were saved in MATLAB format (R2024a) and filtered using a high order, FIR low pass filter with a 75Hz cutoff frequency in order to reduce baseline noise. Each wave was then processed by the BIOPAC Systems analysis application to identify P wave start, QRS complex, and T wave parameters. From the identified parameters, the PR Interval, QRS Interval, ST Segment, QT Interval, T Wave duration, and RR Interval times (ms) were measured for each beat. Next, outlier detection and removal were implemented using the interquartile range method. Specifically, for each set of measurements, the 25$^{th}$ percentile, 50$^{th}$ percentile (median), and 75% percentile are determined. The interquartile range (IQR) is defined as the difference between the 75% percentile and 25% percentile values. Outliers are identified as any values in the set of measurements that is greater than the median + 1.5*IQR or less than the median – 1.5*IRQ. With the outliers removed from the measurement set, the summary statistics were completed for each electrogram parameter of

each camel and are shown in Table 2. Secondary measures included corrected QTc interval, HR and short-term Heart Rate Variability (HRV) values. QTc was determined using the Bazett's formula where QTc is computed as the QT interval divided by the square root of the associated RR interval. The HR was determined from the RR Interval and standard deviation of the normal RR Interval (SDNN) was used to determine the short-term HRV.

**Statistical analysis:** The ECG and Se data from 20 camels were analysed using IBM SPSS (Version 31.0.1.0. (49). The mean, standard deviation (STD), standard error (SE), maximum, minimum values, median, range and interquartile range were analyzed. Camels 7, 17, and 19 were removed from the summative analysis due to excessive pre-ventricular contractions (PVC), excessive baseline noise, and excessive bradycardia, respectively, for a total n = 17.

## Results

The cohort of camels included a group of apparently healthy adult female animals weighing 406±7 kg (n=20) and aged 9.8±0.3 yrs (n=20). Se was measured in blood serum and hair and the results are shown in Table 1. Se content of hair was 0.61±0.05 (n=20) and ranged from 0.25 to 1.28 mg/kg. Se content of blood serum was 133±10 ng/ml (n=20) and ranged from 59 to 230 ng/ml (Table 1).

Electrocardiographic measurements included interval measurements of the P wave, QRS wave and T wave and also HR and HRV are shown in Table 2. HR was 54±3 BPM (n=17) and HRV was 141±21 ms (n=17). Configuration of the P, QRS and T varied. Deflection of the P wave was always +ve. Deflection of the QRS complex was -ve or bidirectional. Deflection of the T wave was +ve, bidirectional or -ve (Table 2 and Fig 2). The ECGs displayed various arrhythmias, some of which are displayed in Fig 3.

The correlation coefficient for all comparison was determined using the Pearson's r method, where | r | = 1 implies a perfect correlation. For each comparison, there was no observable correlation in the scatter graphs (Figs 4 and 5) and the absolute correlation coefficient, | r |, was less than 0.5. Specific comparisons include PR Interval vs. serum Se (Fig 4A), QRS Interval vs. serum Se (Fig 4B), QTc Interval vs. serum Se (Fig 4C), HR vs. serum Se (Fig 4D), PR Interval vs. hair Se (Fig 5A), QRS Interval vs. hair Se (Fig 5B), QTc Interval vs. hair Se (Fig 5C) and HR vs. hair Se (Fig 5D).

## Discussion

This study examined the relationship between Se status and ECG parameters in a cohort of apparently healthy adult female dromedary camels. The principal finding is that, within the physiological range of Se concentrations observed in serum (133±10 ng/ml) and hair (0.61±0.05 mg/kg), there were no significant associations with key ECG indices, including PR interval, QRS duration, QTc interval, or HR. These findings indicate that normal variation in Se status does not influence resting cardiac electrical activity in healthy camels.

**Table 1.** Camel ID, weight (kg) age (years) and selenium level measured in hair and blood serum. Summative statistics include animal count, mean, standard deviation, standard error, maximum, minimum, median, range, and interquartile range (IQR).

| Camel ID | Weight (kg) | Age (yrs) | Hair Se (mg/kg) | Serum Se (ng/ml) |
|---|---|---|---|---|
| 1 | 400 | 10 | 1.045 | 168 |
| 2 | 410 | 9 | 0.617 | 118 |
| 3 | 405 | 12 | 0.689 | 171 |
| 4 | 400 | 10 | 0.659 | 166 |
| 5 | 480 | 10 | 0.400 | 136 |
| 6 | 450 | 9 | 0.249 | 171 |
| 7 | 375 | 8 | 0.426 | 131 |
| 8 | 410 | 9 | 0.837 | 182 |
| 9 | 426 | 10 | 0.369 | 110 |
| 10 | 397 | 10 | 0.553 | 230 |
| 11 | 450 | 10 | 0.527 | 150 |
| 12 | 428 | 12 | 0.402 | 102 |
| 13 | 403 | 10 | 1.282 | 126 |
| 14 | 379 | 9 | 0.559 | 160 |
| 15 | 395 | 10 | 0.549 | 59 |
| 16 | 382 | 10 | 0.541 | 59 |
| 17 | 386 | 9 | 0.535 | 64 |
| 18 | 350 | 8 | 0.511 | 86 |
| 19 | 393 | 9 | 0.563 | 184 |
| 20 | 410 | 12 | 0.795 | 94 |
| | | | | |
| **Count** | 20 | 20 | 20 | 20 |
| **Average** | 406 | 9.8 | 0.61 | 133 |
| **STD** | 29 | 1.2 | 0.24 | 47 |
| **SE** | 7 | 0.3 | 0.05 | 10 |
| **Max** | 480 | 12.0 | 1.28 | 230 |
| **Min** | 350 | 8.0 | 0.25 | 59 |
| **Median** | 402 | 10.0 | 0.55 | 134 |
| **Range** | 130 | 4.0 | 1.03 | 171 |
| IQR | 23 | 1.0 | 0.18 | 69 |

**Table 2.** Camel number, weight (kg) age (years), electrocardiographic interval measurements and deflections of the P Wave, QRS Wave, and T Wave. Summative statistics include animal count, mean, standard deviation, standard error, maximum, minimum, median, range, and interquartile range (IQR). Camels 7, 17, and 19 were removed from the summative analysis due to excessive pre-ventricular contractions (PVCs), excessive baseline noise, and excessive bradycardia.

| Camel Idx | Weight (kg) | Age (yrs) | PR Int (ms) | QRS Int (ms) | T Int (ms) | QT (ms) | QTc (ms) | ST (ms) | RR (ms) | HR (BPM) | HRV (ms) | P Wave Def | QRS Def | T Wave Def |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 400 | 10 | 286 | 99 | 195 | 548 | 425 | 254 | 1673 | 37 | 319 | ↑ | ↓ | ↓ |
| 2 | 410 | 9 | 266 | 81 | 122 | 405 | 390 | 202 | 1089 | 55 | 52 | ↑ | ↕ | ↕ |
| 3 | 405 | 12 | 307 | 85 | 133 | 394 | 420 | 180 | 924 | 65 | 67 | ↑ | ↓ | ↑ |
| 4 | 400 | 10 | 311 | 89 | 86 | 403 | 403 | 226 | 978 | 61 | 41 | ↑ | ↓ | ↑ |
| 5 | 480 | 10 | 217 | 108 | 121 | 453 | 456 | 223 | 981 | 60 | 94 | ↑ | ↕ | ↓ |
| 6 | 450 | 9 | 206 | 88 | 136 | 431 | 404 | 203 | 1158 | 52 | 94 | ↑ | ↕ | ↓ |
| 8 | 410 | 9 | 269 | 106 | 134 | 471 | 389 | 223 | 1506 | 40 | 141 | ↑ | ↕ | ↓ |
| 9 | 426 | 10 | 276 | 93 | 175 | 488 | 438 | 211 | 1383 | 45 | 254 | ↑ | ↕ | ↓ |
| 10 | 397 | 10 | 219 | 98 | 128 | 462 | 445 | 234 | 1083 | 55 | 88 | ↑ | ↕ | ↓ |
| 11 | 450 | 10 | 217 | 98 | 107 | 404 | 430 | 196 | 880 | 68 | 47 | ↑ | ↕ | ↓ |
| 12 | 428 | 12 | 226 | 97 | 92 | 362 | 403 | 167 | 810 | 73 | 82 | ↑ | ↕ | ↑ |
| 13 | 403 | 10 | 340 | 91 | 121 | 469 | 430 | 252 | 1115 | 53 | 164 | ↑ | ↕ | ↓ |
| 14 | 379 | 9 | 258 | 102 | 136 | 399 | 459 | 157 | 770 | 78 | 142 | ↑ | ↕ | ↕ |
| 15 | 395 | 10 | 312 | 114 | 149 | 512 | 457 | 254 | 1207 | 50 | 131 | ↑ | ↕ | ↕ |
| 16 | 382 | 10 | 352 | 89 | 125 | 484 | 392 | 264 | 1478 | 41 | 271 | ↑ | ↓ | ↕ |
| 18 | 350 | 8 | 306 | 103 | 179 | 534 | 482 | 251 | 1134 | 50 | 150 | ↑ | ↓ | ↕ |
| 20 | 410 | 12 | 271 | 96 | 138 | 455 | 351 | 219 | 1672 | 36 | 262 | ↑ | ↕ | ↕ |
| | | | | | | | | | | | | | | |
| **Count** | 17 | 17 | 17 | 17 | 17 | 17 | 17 | 17 | 17 | 17 | 17 | | | |
| **Mean** | 410 | 10 | 273 | 96 | 134 | 451 | 422 | 218 | 1167 | 54 | 141 | | | |
| **STD** | 30 | 1.1 | 45 | 9 | 29 | 53 | 33 | 32 | 283 | 12 | 87 | | | |
| **SE** | 7 | 0.3 | 11 | 2 | 7 | 13 | 8 | 8 | 69 | 3 | 21 | | | |
| **Max** | 480 | 12.0 | 352 | 114 | 195 | 548 | 482 | 264 | 1673 | 78 | 319 | | | |
| **Min** | 350 | 8.0 | 206 | 81 | 86 | 362 | 351 | 157 | 770 | 36 | 41 | | | |
| **Median** | 405 | 10.0 | 271 | 97 | 133 | 455 | 425 | 223 | 1115 | 53 | 131 | | | |
| **Range** | 130 | 4.0 | 146 | 33 | 109 | 186 | 131 | 107 | 903 | 42 | 278 | | | |
| **IQR** | 29 | 1.0 | 81 | 12 | 16 | 80 | 42 | 49 | 404 | 17 | 81 | | | |

The measured Se concentrations in serum were comparable to values previously reported in camels from similar geographical regions and management systems. Hamliri *et al* (1990) performed a study in male and female camels between 3 and 16 years of age. In camels aged 10-15 years the whole blood Se concentration was 112.9±15.2 ng/ml. Zongping (2003) performed a study in male and female camels 2-13 years of age. Se concentrations were 0.29±0.09 mg/kg in blood and 0.22±0.15 mg/kg in hair. Faye *et al* (2005) performed a study in male and female camels between 2 and 10 years of age. In camels greater than 7 years of age Se serum concentration was 12.4 µg/100 ml and was higher in female (22.9 µg/100 ml) compared to male (13.6 µg/100 ml) camels. Seboussi *et al* (2008) performed a study in 12 healthy female camels 6 to 12 years of age. The mean value of Se content in plasma was 275.1±125.7 ng/ml and varied between 91.6 and 596.6 ng/ml. Elrayah *et al* (2010) performed a study in 500 male and female camels in age groups ranging from less than 5 years to greater than 10 years of age showing differences by geographic location and age. Se in serum of >10 year old camels was 128±5.97 ng/ml. Seboussi *et al* (2010) performed a study in 8 young female camels exposed to different levels of dietary Se. Se concentration was measured in blood and different organs. In blood serum Se was increased significantly in Se supplemented groups with an average of 176.3±18 ng/ml in the control group, rising to 382.7±107.6 ng/ml in the group receiving 2 mg Se, 519.8±168.4 ng/ml in the group receiving 4 mg Se,

and 533.4±158.6 ng/ml in the group receiving 8 mg Se daily. In hair the Se concentrations were 80.7 µg/kg in control group, 163.6 in the group receiving 2 mg Se, 563.2 in the group receiving 4 mg Se and 1130.7 µg/kg in the group receiving 8 mg Se supplementation. Abdelrahman *et al* (2022) reported regional and seasonal variations in Se.

Considerable inter-individual variability in Se status was evident, consistent with known influences of soil Se content, forage composition, dietary supplementation, age, and sex. Despite this variability, ECG parameters remained within established reference ranges for camels, suggesting that Se levels in the present cohort were adequate to maintain normal myocardial electrophysiological function.

Experimental studies in rodents and other species have demonstrated clear electrophysiological disturbances associated with both Se deficiency and Se excess, including alterations in ECG, action potential duration, repolarization abnormalities, and increased susceptibility to arrhythmias (Godwin, 1965; Godwin and Fraser, 1966; Wildman *et al,* 1994; Ayaz *et al,* 2007). These effects are largely attributed to impaired antioxidant defense, disrupted redox regulation, and direct modulation of cardiac ion channels and calcium-handling proteins (Sayar *et al,* 2000; Ayaz *et al,* 2004; Ayaz *et al,* 2005; Okatan *et al,* 2013). However, many of these effects have been observed under conditions of metabolic stress, ischemia, diabetes, or experimentally induced Se imbalance. In contrast, studies in healthy animals with sufficient antioxidant reserves have reported minimal electrophysiological consequences of isolated variation in Se intake (Ringstad *et al,* 1988). The absence of correlation between Se status and ECG parameters in the present study is therefore consistent with the concept that Se-related cardiac electrical effects are highly context-dependent.

Marked variability in ECG waveform morphology was observed, particularly in QRS and T wave configurations. Similar variability has been reported in previous camel ECG studies and is likely attributable to species-specific cardiac anatomy, heart orientation within the thorax, electrode positioning, and body size rather than biochemical influences (Howarth *et al,* 2025). Occasional arrhythmias, including premature ventricular contractions and pronounced bradycardia, were identified in a small number of animals; however, these cases were not associated with extreme Se concentrations and were therefore unlikely to be Se-mediated.

Hair Se measurement provided an index of longer-term Se exposure, complementing serum measurements that reflect more recent intake. The lack of association between hair Se and ECG parameters further supports the conclusion that chronic Se status, within the observed physiological range, does not affect resting cardiac electrophysiology in healthy camels.

Several limitations should be acknowledged. The study was limited to adult female camels and to resting ECG recordings, and it did not include animals with confirmed Se deficiency or selenosis. Based on the literature review, the electrocardiogram can be affected by Se deficiency, which was not observed in this study. It is possible that Se-related electrophysiological effects may become apparent during exercise, physiological stress, ischemia, or disease states. In addition, subtle cellular or molecular effects of Se on cardiac ion channels may not be detectable using surface ECG recordings alone.

In conclusion, this study demonstrates that in apparently healthy adult female dromedary camels, physiological variation in Se status is not associated with alterations in standard ECG parameters. These findings support the view that Se-related cardiac electrophysiological effects are primarily evident under conditions of nutritional imbalance or pathological stress, rather than during normal physiological homeostasis.

## Conclusion

In the group of apparently healthy adult female camels there were no associations between blood serum Se and a range of electrocardiographic parameters including serum Se and PR interval, QRS interval, QTc interval and HR.


## Acknowledgements

The authors would like to acknowledge the support of the technical and handling staff at the Camel Research Centre, Al Ain.

## Funding

The project was supported by a SURE+ Grant from UAE University and a Project Grant from the College of Medicine and Health Sciences.


## Ethical Statement

This study was done according to the guidelines of the Declaration of Helsinki.

## Data Availability

The data generated during the study can be requested from the corresponding author.

## Conflict of Interest

The authors declare no conflict of interest.

## References


Abdelrahman MM, Alhidary IA, Aboragah AA, Qaid MM, Al-Badwi MA, Matar AM, Alobre MM, Amran RA and Aljumaah RS. Maternal and Environmental Drivers of Trace Mineral Dynamics in Camel Dams and Neonates Across Regions and Seasons in Saudi Arabia. Life (Basel) 15. 2025.

Abdelrahman MM, Alhidary IA, Aljumaah RS and Faye B. Blood Trace Element Status in Camels: A Review. Animals (Basel) 12. 2022a

Abdelrahman MM, Alhidary IA, Alobre MM, Matar AM, Alharthi AS, Faye B and Aljumaah RS. Regional and Seasonal Variability of Mineral Patterns in Some Organs of Slaughtered One-Humped Camels. Animals (Basel) 12. 2022b.

Acosta-Dacal A, Melián Henríquez A, Corbera JA, Macías-Montes A, Zumbado M, Ruiz-Suárez N, Martín-Barrasa JL, Luzardo OP and Tejedor-Junco MT. Comprehensive profiling of essential elements and organic and inorganic contaminants in dromedary camels from the canary islands: A baseline for nutritional and environmental assessment. Veterinary Sciences. 2025; 12:1-17.

Al-Qarawi A, Abbas B, Haroun E, Mahmoud O and Al-Hawas A. Clinicopathological investigation of selenium responsive myopathy in young adult camels. Journal of Camel Practice and Research. 2001; 8:23-27.

Ali A, Derar DR, Abdel-Elmoniem EM and Almundarij TI. Impotentia generandi in male dromedary camels: heavy metal and trace element profiles and their relations to clinical findings and semen quality. Tropical Animal Health and Production. 2019; 51:1167-1172.

Ali A, Derar DR, Alhassun TM and Almundarij TI. Effect of zinc, selenium, and vitamin E administration on semen quality and fertility of male dromedary camels with Impotentia Generandi. Biological Trace Element Research. 2021; 199:1370-1376.

Ardahanli I and Ozkan HI. Comparison of serum selenium levels between patients with newly diagnosed atrial fibrillation and normal controls. Biological Trace Element Research. 2022; 200:3925-3931.

Ayaz M, Dalkilic N, Bariskaner H, Tuncer S and Demirel I. Gender-dependent effects of selenite on the perfused rat heart: a toxicological study. Biological Trace Element Research. 2007; 116:301-310.

Ayaz M, Ozdemir S, Ugur M, Vassort G and Turan B. Effects of selenium on altered mechanical and electrical cardiac activities of diabetic rat. Archives of Biochemistry and Biophysics. 2004; 426:83-90.

Ayaz M, Ozdemir S, Yaras N, Vassort G and Turan B. Selenium-induced alterations in ionic currents of rat cardiomyocytes. Biochemical and Biophysical Research Communications. 2005; 327:163-173.

Barri M and Al-Sultan S. Studies on selenium and vitamin E status of young Megaheem dromedary camels at Al-Ahsa province. Journal of Camel Practice and Research. 2007; 14:51-53.

Bataa B, Motohira K, Dugar D, Sainnokhoi TA, Gendenpil L, Sainnokhoi T, Pelden B, Yohannes YB, Ganzorig S, Nakayama SMM, Ishizuka M and Ikenaka Y. Accumulation of Metals in the Environment and Grazing Livestock near A Mongolian Mining Area. Toxics 10. 2022.

Braun K, Rosenberg SZ and Bellin L. The electrocardiogram of a camel. American Heart Journals. 1958; 55:754-757.

Corbera JA, Gutierrez C, Morales M, Montel A and Montoya JA. Assessment of blood glutathione peroxidase activity in the dromedary camel. Veterinary Research. 2001; 32:185-191.

Dallak M. A synergistic protective effect of selenium and taurine against experimentally induced myocardial infarction in rats. Archives of Biochemistry and Biophysics. 2017; 123:344-355.

El-Khouly A, Abbas T and Moustafa T. Myocardial dystrophy in camel calves in the United Arab Emirates (field cases). Emirates Journal of Agricultural sciences. 2001; 13:11-17.

Elrayah H, Barri M and Abdelrahman S. Trace elements level in camels (*Camelus dromedarius*) Western Sudan (Kordofan State). Journal of Camel Practice and Research. 2010; 17:263-267.

Fairweather-Tait SJ, Bao Y, Broadley MR, Collings R, Ford D, Hesketh JE and Hurst R. Selenium in human health and disease. Antioxid Redox Signal. 2011; 14:1337-1383.

Fantinato E and Binanti D. Pathology in Practice. Acute to subacute multifocal to coalescing necrosis of the myocardium. Journal of the American Veterinary Medical Association. 2015; 247:1023-1025.

Faye B and Bengoumi M. Trace-elements status in camels. A review. Biological Trace Element Research. 1994; 41:1-11.

Faye B and Seboussi R. Selenium in camel--a review. Nutrients. 2009; 1:30-49.

Faye B, Seboussi R and Askar M. Trace elements and heavy metals in healthy camel blood of United Arab Emirates. Journal of Camel Practice and Research. 2005; 12.

Gasmi A, Garnier R, Galliot-Guilley M, Gaudillat C, Quartenoud B, Buisine A and Djebbar D. Acute selenium poisoning. Veterinary and Human Toxicology. 1997; 39:304-308.

Godwin KO. Abnormal electrocardiograms in rats fed a low selenium diet. Quarterly Journal of Experimental Physiology and Cognate Medical Sciences. 1965; 50:282-288.

Godwin KO and Fraser FJ. Abnormal electrocardiograms, blood pressure changes, and some aspects of the histopathology of selenium deficiency in lambs. Quarterly Journal of Experimental Physiology and Cognate Medical Sciences. 1966; 51:94-102.

Gutierrez C, Corbera JA, Morales I, Morales M and Navarro R. Uterine prolapse in 2 dromedary camels. Canadian Veterinary Journal. 2001; 42:803-804.

Hamliri A, Khallaayoune K, Johnson DW and Kessabi M. The relationship between the concentration of selenium in the blood and the activity of glutathione peroxidase in the erythrocytes of the dromedary camel (*Camelus dromedarius*). Veterinary Research Communications. 1990; 14:27-30.

Howarth F, Tinson A, Baniyas S, Alderei M, Aldhaheri D, Adeghate E, Dobrzynski H and Jacobson M. Electrocardiographic measurements in the camel (*Camelus dromedarius*). Journal of Camel Practice and Research. 2025; 32(3):6.

Kieliszek M. Selenium-Fascinating Microelement, Properties and Sources in Food. Molecules. 2019; 24.

Meligy AMA, El-Ghareeb WR, Abdel-Raheem SM, Ismail HAA, Darwish WS, Kandeel M, Alfifi AE, Al-Shokair SS and Hussein MA. Assessment of some toxic elements (Co, Cr, Mn, Se, and As) in muscle, offal, hair, and blood of camels. Open Veterinary Journal. 2024; 14:154-163.

Okamoto T, Mizuta K, Takahashi T, Kishi T, Kitahara S, Komori S, Hashimoto K and Goshima K. Protective effect of gamma-glutamylcysteinylethyl ester on dysfunction of the selenium-deficient rat heart. Biochemical Pharmacology. 1999; 57:955-963.

Okatan EN, Tuncay E and Turan B. Cardioprotective effect of selenium via modulation of cardiac ryanodine receptor calcium release channels in diabetic rat cardiomyocytes through thioredoxin system. Journal of Nutritional Biochemistry. 2013; 24: 2110-2118.

Pourjafar M, Badiei K, Chalmeh AA, Naghib SM, Abdolhoseinzadeh M and Pourmirzaei H. Standard electrocardiographic parameters of base apex lead system in different age groups of clinically healthy dromedary camel (*Camelus dromedarius*). Journal of Camel Practice and Research. 2011; 18:4.

Rayman MP. Selenium and human health. Lancet. 2012; 379:1256-1268.

Ringstad J, Tande PM, Norheim G and Refsum H. Selenium deficiency and cardiac electrophysiological and mechanical function in the rat. Pharmacology and Toxicology. 1988; 63:189-192.

Samimi AS and Sanjarinejad A. Effects of two-dose intravenous administration of furosemide on clinical variables, electrocardiographic indices and serum electrolytes in dromedary calves. Veterinary Medicine and Science. 2021; 7:1185-1190.

Sayar K, Ugur M, Gürdal H, Onaran O, Hotomaroglu O and Turan B. Dietary selenium and vitamin E intakes alter beta-adrenergic response of L-type Ca-current and beta-adrenoceptor-adenylate cyclase coupling in rat heart. Journal of Nutrition. 2000; 130:733-740.

Schomburg L. Selenoprotein P - Selenium transport protein, enzyme and biomarker of selenium status. Free Radical Biology and Medicine. 2022; 191:150-163.

Seboussi R, Faye B, Alhadrami G, Askar M, Bengoumi M and Elkhouly A. Chronic selenosis in camels. Journal of Camel Practice and Research. 2009a; 16:25-38.

Seboussi R, Faye B, Alhadrami G, Askar M, Ibrahim W, Hassan K and Mahjoub B (2008). Effect of different selenium supplementation levels on selenium status in camel. Biological Trace Element Research. 2009a; 123:124-138.

Seboussi R, Faye B, Alhadrami G, Askar M, Ibrahim W, Mahjoub B, Hassan K, Moustafa T and Elkhouly A. Selenium distribution in camel blood and organs after different level of dietary selenium supplementation. Biological Trace Element Research. 2010; 133:34-50.

Seboussi R, Faye B, Askar M, Hassan K and Alhadrami G. Effect of selenium supplementation on blood status and milk, urine, and faecal excretion in pregnant and lactating camel. Biological Trace Element Research. 2009b; 128:45-61.

Shahin MA, Khalil WA, Saadeldin IM, Swelum AA and El-Harairy MA (2021). Effects of vitamin C, vitamin E, selenium, zinc, or their nanoparticles on camel epididymal spermatozoa stored at 4°C. Tropical Animal Health and Production. 2009b ; 53:86.

Sinci V, Yildirim S and Turan B. Effects of selenium-enriched reperfusion solutions on isolated guinea pig hearts. Biological Trace Element Research. 1998; 65(3):243-259.

Ugur M and Turan B. Adenosine triphosphate alters the selenite-induced contracture and negative inotropic effect on cardiac muscle contractions. Biological Trace Element Research. 2001; 79:235-245.

Venardos K, Harrison G, Headrick J and Perkins A. Effects of dietary selenium on glutathione peroxidase and thioredoxin reductase activity and recovery from cardiac ischemia-reperfusion. Journal of Trace Elements in Medicine and Biology. 2004; 18:81-88.

Wildman RE, Medeiros DM and Jenkins J. Comparative aspects of cardiac ultrastructure, morphometry, and electrocardiography of hearts from rats fed restricted dietary copper and selenium. Biological Trace Element Research. 1994; 46:51-66.

Zhu YH, Wang XF, Yang G, Wei J, Tan WH, Wang LX, Guo X, Lammi MJ and Xu JH. Efficacy of long-term selenium supplementation in the treatment of chronic keshan disease with congestive heart failure. Current Medical Science. 2019; 39:237-242.

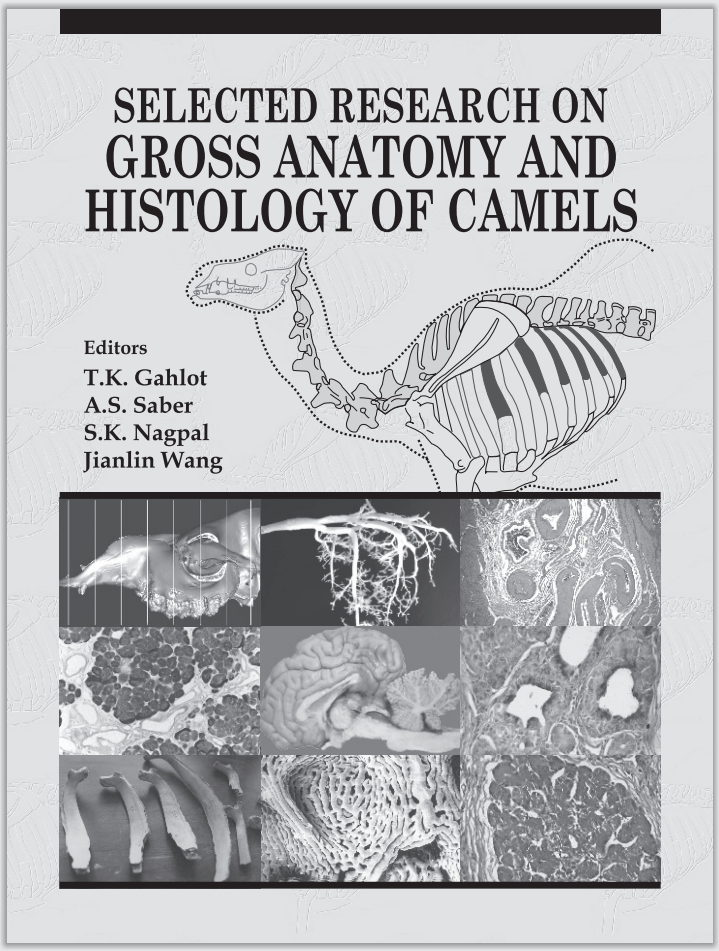
Zongping L. Studies on the haematology and trace element status of adult Bactrian camels (*Camelus bactrianus*) in China. Veterinary Research Communications. 2003; 27:397-405.

Özdemir O, Çiftçi M, Hatipoğlu F, Ortatatlı M, Yavuz O and Kanat O. Nutritional cardiomyopathy in a young camel (*C. dromedarius*). Eurasian Journal of Veterinary Sciences. 2016; 32:52-54.

# 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

DOI : 10.5958/2277-8934.2026.00002.7 Vol 33 No 1, p 11-23

# DYNAMICS AND CONSTRAINTS OF CAMEL PRODUCTION IN MOROCCO: A REVIEW

**Fadwa Guimimi[1], Bouchra El Amiri[2,3], Hind Mkadem[1], Mohamed Mouncif[1] and Ali Hajji[1]**

[1]Hassan II Agronomic and Veterinary Institute, Madinat Al Irfane, P.O. Box 6202. Rabat, Morocco

[2]Animal Production Unit, Regional Center Agricultural Research of Settat, National Institute for Agricultural Research (INRA), Avenue Ennasr, Rabat Principal, P.O. Box 415, 10090, Rabat, Morocco

[3]African Sustainable Agriculture Research Institute (ASARI), Mohammed VI Polytechnic University (UM6P), Laayoune 70000, Morocco

## ABSTRACT

For centuries, pastoralism has been one of the main pillars of livelihood systems in Morocco's arid and semi-arid regions. This traditional production system is now facing increasing environmental pressures and profound transformations driven by climate variability and socio-economic change across rural areas. As these pressures intensify, the dromedary remains a vital resource owing to its unique adaptive capacity to harsh environments. It occupies a distinctive position among livestock species: its market value tends to be more resilient during times of crisis and it remains the most valuable animal within both pastoral and agro-pastoral systems. More than 90% of the national camel population is concentrated in the southern regions of the country. This review paper examines the current status and dynamics of Morocco's camel population, highlighting the main socio-economic drivers, constraints and opportunities within the sector. Available data indicate fluctuating herd trends, with a declining tendency in recent years. Although the marketing and processing of camel products remain limited, the sector is showing early signs of expansion and demonstrates considerable development potential. The camel sector continues to receive limited institutional and scientific attention and still faces major structural constraints, particularly recurrent drought, rangeland degradation and restricted market access.

**Key words:** Arid and semi arid zones, camel population, *Camelus dromedarius*, morocco, pastoralism, sustainable livestock development

Morocco presents a remarkable diversity of agro-ecological zones, ranging from Atlantic plains to Saharan areas, offering a wide variety of conditions for livestock production. Approximately 93% of Morocco's territory is classified as arid to semi-arid, reflecting the predominance of dry and very dry environments across the country and providing an ecological context highly favourable to pastoral systems (Dahan *et al*, 2012).

In Morocco, the livestock sector plays a crucial role in both the agricultural and rural economy. Its direct contribution to the agricultural GDP is estimated at 30–35%, while it accounts for nearly 10% of the national GDP, according to the Moroccan Ministry of Agriculture's Green Morocco Plan review report (2019). When related activities such as processing, marketing and value addition of animal products are included, the contribution of livestock to national agricultural value added exceeds 40%. Although the livestock sector has traditionally supported rural livelihoods and contributed to national food security (FAO, 2022), its stability has been severely challenged in recent years due to exceptional climatic and economic pressures. Morocco is now experiencing structural water stress, with renewable water availability falling below 730 $m^3$ per capita per year, well under the commonly used water-stress threshold of 1,000 $m^3$ (World Bank, 2020). In 2023/2024, Morocco experienced one of the most severe crises affecting pastoral and livestock systems, marked by a sharp increase in the prices of forage, compound feed and red meat. Severe and recurrent droughts drastically reduced rangeland biomass and local forage production, forcing farmers to rely heavily on commercial feedstuffs whose prices rose sharply. The study conducted in the province of Taza demonstrates that meteorological drought leads to a significant rise in straw and feed prices while simultaneously reducing animal productivity and market value (Belmahi *et al,* 2023). At the national scale, this surge in input costs was further exacerbated by global increases in cereal and soybean prices and by Morocco's structural dependence on imported feed

SEND REPRINT REQUEST TO FADWA GUIMIMI email: f.guimimi@iav.ac.ma

components, which intensified inflationary pressures across the agri-food system. Benayad (2024) highlights that food inflation has become a major vulnerability within the ongoing transformation of the Moroccan agri-food sector. The economic burden on livestock producers is considerable: Dahmani, Julien and Sraïri (2025) report that feed costs may account for up to 80 to 87% of total production expenses in sheep systems, making these systems extremely sensitive to any rise in input prices. Taken together, these studies show how drought-induced forage scarcity, global market volatility and growing dependence on external inputs have converged to undermine the stability of the livestock sector and to drive the substantial increase in production costs and meat prices observed in Morocco in 2023/2024.

The dromedary is among the animal species best adapted to arid and semi-arid zones worldwide. While camel husbandry is highly developed in the arid lowlands of East Africa, Morocco, belonging to the Saharan and pre-Saharan zones of North Africa, offers similar ecological conditions favourable to camel breeding. Camel production systems in Morocco are largely extensive and pastoral, characterised by high herd mobility, particularly in Saharan regions (Michel *et al,* 1997). The national camel population is currently estimated at around 106044 heads, according to the most recent statistics from the Moroccan Ministry of Agriculture (MAPM, 2025). The highest concentrations of camels are found in the southern provinces, namely Guelmim-Oued Noun, Laâyoune-Sakia El Hamra and Dakhla-Oued Eddahab, which together account for more than 80% of the national herd (MAPM, 2020).

Owing to their exceptional tolerance to heat, drought and feed scarcity, dromedaries stand out as the most resilient domestic species in arid and semi-arid ecosystems, capable of sustaining the production of milk, meat and services under harsh environmental conditions (Bengoumi and Faye, 2015). Given the strategic importance of this species for pastoral communities and for the sustainable development of arid regions, a comprehensive assessment of the current state of the Moroccan camel sector is warranted. The present work therefore provides a literature review analysing national camel production, its constraints and the emerging opportunities for its future development.

## Current status and evolution of camel populations in Morocco

In 2023, the global dromedary population was estimated at about 43 million head (FAOSTAT, 2023). In Africa, the camel population was estimated at about 34 million head in 2021, nearly ten times lower than the numbers of cattle, sheep or goats (Faye *et al,* 2025). In North Africa, only dromedaries are found and Morocco is among the leading camel-breeding countries of the region (Faye *et al,* 2014). In this review, the term camel production refers exclusively to the dromedary species.

In Morocco, nearly 90% of camel production is concentrated in the Saharan and pre-Saharan zones of the southern regions, namely Laâyoune-Sakia El Hamra, Dakhla-Oued Eddahab and Guelmim-Oued Noun, forming what is commonly referred to as the Moroccan camel belt (Amsidder *et al,* 2021; Kamili *et al,* 2020). This distribution is confirmed by Julien *et al* (2021), who also highlighted the importance of the Drâa-Tafilalet valley, located in the south and south-east of the country, as a complementary camel-breeding area. In these regions, camel milk is mainly consumed raw, although several initiatives are now promoting the diversification and processing of camel products (El Hatmi *et al,* 2015; Faye and Bonnet, 2012).

Estimates of the camel population in Morocco vary depending on the source (Fig 1). The national livestock inventory conducted by the Moroccan Ministry of Agriculture reported 254000 dromedaries up to 2019, while the most recent census, carried out in 2025, indicated a marked decline to 106044 head, including 91432 females. This regression has been attributed mainly to successive drought years (MAPM, 2025). According to Faye *et al* (2025), Morocco's camel population was estimated at approximately 175 505 head in 2023, with a density of 24.63 head per 100 km², 4.65 dromedaries per 1000 inhabitants and a negative annual growth rate of –1.22 % between 1961 and 2023, reflecting a trend of stagnation linked to the reduction of pastoral rangelands and the progressive sedentarisation of herders.

A certain regularity can be observed in the FAO data series presented in the Fig 1, although these are partly based on estimates (from 2008 to 2017) rather than those officially reported. Moreover, a notable discrepancy appears between the values reported by the FAO and those derived from national statistics. According to Faye *et al* (2025), the data reported by the FAO are underestimated and do not fully reflect the actual number of dromedaries present in Morocco. Consequently, all available sources indicate an irregular evolution of the camel herd, placing Morocco among the countries characterised by low or even stagnant growth in camel population numbers.

Analysis of the trend in the Moroccan camel herd shows an increase in population size between 2008 and 2012, followed by an estimated decline at 44.2 % between 2012 and 2025, (Fig 2). This fluctuating trend has been confirmed by several studies, which specifically attribute the downward phase to factors such as repeated droughts and the marginalisation of pastoral systems. However, certain regions have shown signs of stabilisation or even a slight recovery, associated with renewed mobility dynamics and local valorisation initiatives (Aayadi *et al,* 2025; Faye *et al,* 2025).

To support the livestock sector, the Moroccan government has implemented a development programme with an overall budget of about 11 billion dirhams. This funding aims to mitigate the effects of adverse climatic conditions on animal production. The resources are distributed as direct subsidies to herders, intended for the purchase of feed, the preservation of breeding stock, the reduction of farmer indebtedness and the organisation of vaccination campaigns and technical support activities. The amount of aid per beneficiary is calculated on the basis of the number of animals recorded and identified by local committees using numbered ear tags (Ibnelbachyr *et al,* 2025; MAPM, 2020).

Several local camel populations are traditionally recognised in Morocco, including Guerzni, Khouari and Marmouri, which are mainly distributed across the Saharan and pre-Saharan regions (Kamili *et al,* 2020; Piro *et al,* 2020; Boujenane *et al,* 2019). Other populations have also been identified by researchers but remain less well known, such as Harcha, Jebli (JmalJbel) (MAPMDRE, 2020; Piro *et al,* 2020). The Guerzni type is generally described as a dromedary with a robust and compact conformation, a well-developed skeletal structure, a large hump and a high load-carrying capacity, which, according to herders, has historically made it the most suitable for harsh pastoral conditions. In contrast, the Marmouri is perceived as a more slender type, with long limbs, a fine body frame and a relatively less developed hump; it is often associated with riding abilities and a better dairy potential. The Khouari is commonly described by herders as an intermediate type, exhibiting morphological characteristics close to those of the Marmouri, but with a greater degree of rusticity. It should be emphasised, however, that these distinctions are primarily based on local knowledge and empirical criteria transmitted within herding communities during our interactions with them and that they do not correspond to populations formally defined on morphometric or genetic bases.

The photographs (Fig 3) illustrate observable morphological diversity among dromedaries; however, no inference is made regarding breeds or populations, as no morphometric or genetic characterisation was performed.

A morphometric study conducted by Piro *et al* (2020) analysed the genetic variability of 227 dromedaries belonging to four local populations (Guerzni, Khouari, Marmouri and Harcha) using 16 microsatellite markers. The results revealed high genetic diversity but low differentiation among most populations, with the exception of the Harcha group, which appeared more distinct. Similarly, the study by Boujenane *et al* (2019) on 132 females from 38 herds across 8 southern provinces confirmed certain morphological differentiations.

This pattern indicates the presence of substantial gene flow among cohabiting zones. These findings suggest that the recognised groups correspond more to phenotypic or ecological types than to distinct breeds in the zootechnical sense, although traditional classification remains deeply rooted and highly valued among herders (Piro *et al,* 2020).

Historically, camel husbandry in Morocco was based on full nomadism, characterised by extensive movements following the availability of pastoral resources (Faye *et al,* 2017). However, recent studies indicate a gradual transformation of these practices towards hybrid forms of mobility. In the south-eastern regions, Amsidder *et al* (2021) observed that although herders still identify themselves as nomadic, their practices now combine seasonal transhumance, opportunistic movements and, in some cases, partial sedentarisation. This transformation is accompanied by multi-activity among herders, the majority of whom engage in non-pastoral income-generating activities and reside in urban areas. This observation is consistent with Kamili *et al* (2020), who, following a survey conducted in nine southern provinces covering 168 herds (representing about 10 % of the regional herd), distinguished different herder profiles according to herd size and market integration: large traditional herders, maintaining a high degree of mobility, small peri-urban herders, who are more sedentary and multi-active herders, who adapt their movements to economic and environmental constraints. These developments illustrate the growing diversity of Moroccan camel

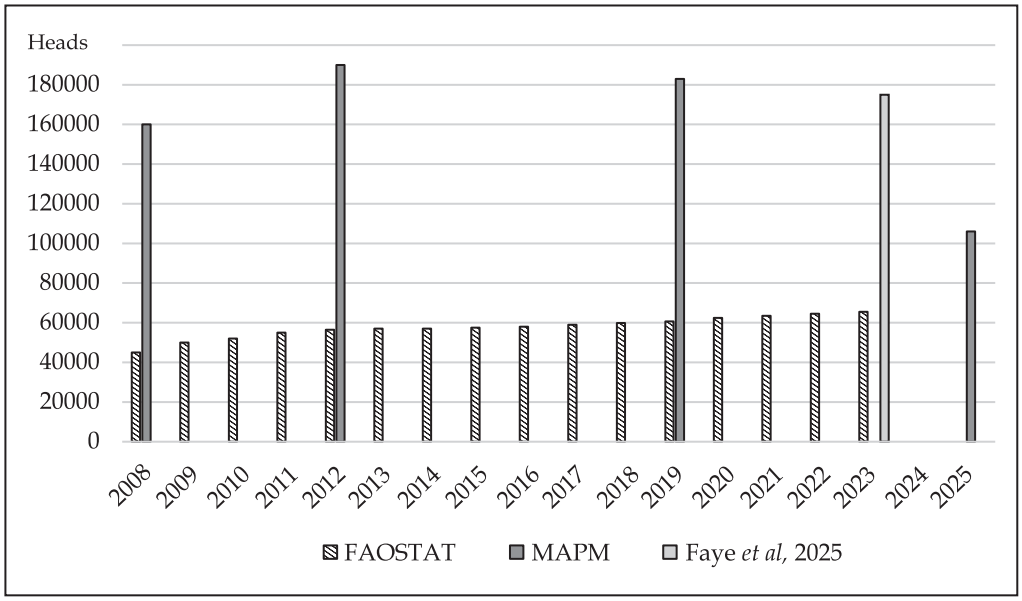



**Fig 1.** Camel population trends in Morocco (Data compiled by the author: MAPM, 2025; Faye *et al,* 2025; FAOSTAT, 2023 (incomplete data); MAPM, 2012).

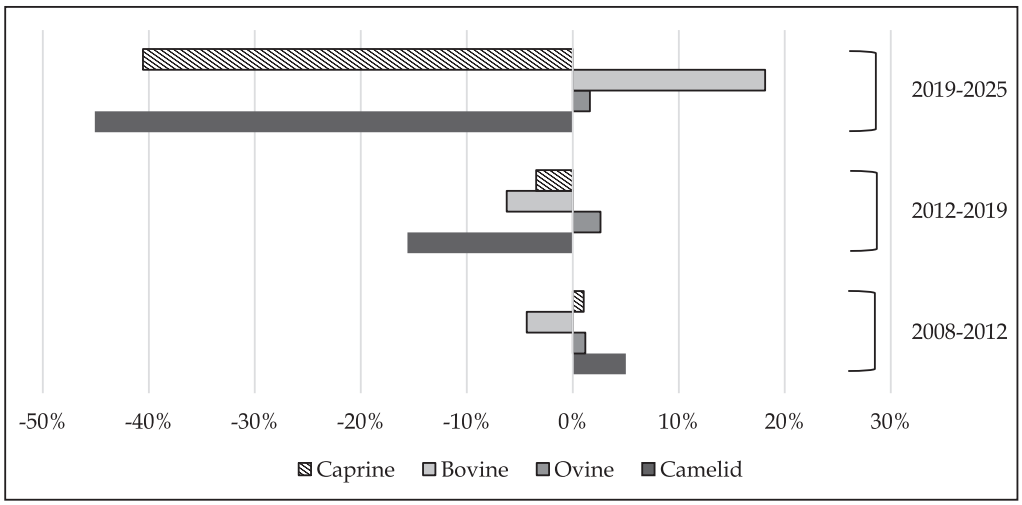



**Fig 2.** Evolution of camel and general livestock populations in Morocco: Percentage variation from 2008 to 2025.

production systems, which no longer correspond solely to the traditional pastoral model but include various adaptive forms. In Guelmim, El Aayadi *et al* (2024), demonstrated that movement patterns reflect a differentiated use of resources: short displacements around water points during the dry season and longer routes towards pre-Saharan areas during periods of greater forage availability.

The economic and demographic performance of camel herds in Morocco is closely linked to the typology of production systems. Highly mobile systems display greater adaptive capacity to climatic variability, whereas small peri-urban units, despite having better access to markets, are more vulnerable to land and feed constraints (Boujenane, 2023; Julien *et al,* 2021). Herd sizes show considerable variability, dominated by small and medium herds (Michel *et al,* 1997), although large herds still exist (Kamili *et al,* 2020).

### *Socio-economic importance of the dromedary in Morocco*

The dromedary occupies a central place within Morocco's pastoral and agro-pastoral systems, particularly in Saharan and pre-Saharan regions, where extreme climatic constraints limit agricultural alternatives. The species also plays a key role in the valorisation of arid and desert areas, as it can exploit plant resources inaccessible to other domestic species, thereby sustaining pastoral activity in marginal lands and ensuring the livelihood security

**Fig 3.** Evolution photographs of dromedary camels (*Camelus dromedarius*) from Dakhla–Oued Eddahab region, Morocco (Photos by authors).


**Fig 4.** Dried dromedary meat (Tichtar) produced by a cooperative in Dakhla (ADA, 2025).


**Fig 5.** Traditional dromedary hump fat (Loudek) produced by a cooperative in Dakhla (ADA, 2025).

of local households (Julien *et al,* 2021). Thanks to its remarkable resilience to water and feed scarcity, the dromedary secures household subsistence while serving as a strategic pillar of food, economic and social security for local communities (Kamili *et al,* 2020). During drought periods, unlike cattle and sheep whose prices collapse, camel prices remain relatively stable or even increase, making the species a true store of value and a security asset for pastoral households (Amsidder *et al,* 2024; Julien *et al,* 2021). In regions such as Guelmim and eastern Morocco, the dromedary provides not only a direct source of income but also a reserve of value convertible into investment, confirming its function as a "security capital" within pastoral livelihood strategies (Alary *et al,* 2021).

Although its contribution to the national livestock population is modest, around 0.32% (Calculated on the basis of the latest 2025 livestock census), its economic and symbolic value far exceeds this proportion, especially in desert provinces where other forms of livestock farming are less viable. Camel production systems in Morocco are multifunctional, encompassing specialised herds (milk or meat), mixed systems combining dromedaries and small ruminants and integrated oasis systems where agriculture and livestock coexist in complementary ways (Kamili *et al,* 2020). This multifunctionality results in a wide range of products and services: milk, meat, fibre, fat, hides, transport, tourism, social capital and symbolic value, that reinforce the cultural embeddedness of the species.

Camel husbandry plays a major economic and social role beyond its productive activities. It constitutes both a source of income and a form of capital that can be mobilised in times of need, as well as a driver of territorial valorisation. Recent analyses have shown that camel products are used in multiple ways, integrating local food systems, traditional medicine and the marketing of live animals, giving the activity both an economic and non-economic dimension (Amsidder *et al,* 2024). Camel milk, for instance, is incorporated into local diets either through direct consumption or traditional processing, while popular medicinal practices continue to rely on its therapeutic properties (Kamili *et al,* 2020). Several studies highlight this diversity of uses and show that the highest profitability is observed in the most diversified systems. Although the sale of live animals remains the main source of income, the multifunctionality of camel products directly enhances household welfare and investment capacity (Amsidder *et al,* 2024).

Household income derives mainly from the sale of milk, meat, live animals and by-products such as hides. Camel milk, in particular, is experiencing growing demand due to its nutritional qualities and its potential for local valorisation (Ibnelbachyr *et al,* 2025). In recent years, several studies conducted in Morocco have deepened current knowledge on the composition and physicochemical characteristics of locally produced camel milk. These works highlight a nutritional profile characterised by good-quality proteins, a low fat content, a favourable mineral balance and relatively stable pH and acidity values compared with other dairy species. The main findings from these studies are summarised in Table 1, which presents the key nutritional parameters and physicochemical characteristics of Moroccan camel milk.

Since 2016, the Protected Geographical Indication (PGI) "Lait de chamelle du Sahara" has covered the regions of Guelmim-Oued Noun, Laâyoune-Sakia El Hamra and Dakhla-Oued Eddahab, thereby enhancing its recognition and commercial potential (Amsidder *et al,* 2024). Initiatives such as the International Agricultural Fair of Morocco (Salon International de l'Agriculture au Maroc, SIAM), the International Fair of Local Products of Agadir (Salon International des Produits du Terroir d'Agadir, SIPTA) and the Local Products Competition (Concours National des Produits du Terroir), organised by the Agricultural Development Agency (ADA) (Figs 4 and 5). These initiatives have encouraged cooperatives and small-scale producers of camel-derived products, thereby contributing to market development.

The social impact has accompanied this growth: the number of jobs related to the camel sector increased from 798 to 2 219 in the Dakhla-Oued Ed-Dahab region and from 740 to 990 in Laâyoune-Sakia El Hamra between 2008 and 2019 (MAPM, 2020). These data confirm that, far from being limited to a traditional pastoral role, the camel sector has become a driver of economic and social development in Saharan regions, with a growing potential for diversification, particularly in milk and meat processing. However, a significant data gap persists concerning the economic value of this activity, which mainly develops in arid and semi arid areas. This shortfall can be explained by the lack of in-depth studies on local dynamics and the micro-actors involved in the sector (Amsidder *et al,* 2024). As a result, a significant share of the economic benefits, particularly those generated at the household level, remains unquantified and unaccounted for an official assessment.

**Marketing and valorisation of the dromedary in Morocco**

The marketing of dromedaries and their derived products in Morocco reveals a sector that is both historically rooted and undergoing profound transformation. The added value of the camel sector increased from approximately 221 to 439 million dirhams (MDH) between 2008 and 2019 (MAPM, 2020). Regional data show that the sector's economic performance has improved markedly in the main active Saharan regions, particularly Dakhla-Oued Ed-Dahab and Laâyoune-Sakia El Hamra. In the former, turnover rose from 45.4 million dirhams in 2008 to 122.5 million in 2019, while added value more than tripled, from 18 to 60 million dirhams. In the latter, the growth has been even more striking: the camel dairy sub-sector's turnover increased exceptionally from 142 million dirhams in 2008 to nearly 484 million in 2019, representing a rise of over +240 % (MAPM, 2020). These results underline the key economic role of the camel sector in regional economies and confirm its structuring and diversification potential beyond traditional pastoralism.

This economic momentum is closely linked to changes in herd size and production levels. In Dakhla-Oued Ed-Dahab, the total herd increased from 9 700 head in 2008 to 24 600 in 2019 and to 40 000 according to the latest figure reported by the Moroccan Minister of Agriculture, while meat production rose from 702 to 900 tonnes over the same period (MAPM, 2020). This growth was also supported by a budget envelope of nearly 99.27 million dirhams allocated to the development of the camel sector within the framework of the Green Morocco Plan (Plan Maroc Vert). The funding was intended to boost milk production by 150 %, targeting 10 million litres by 2020. Although milk production did not reach this figure, it increased from 4 to 6 million litres, reflecting enhanced productivity and local valorisation.

In the Laâyoune-Sakia El Hamra region, which constitutes the country's main camel dairy hub, the milking herd doubled from 50 705 to 105 000 head between 2008 and 2019, raising milk output from 50 to 60.7 million litres (MAPM, 2020). These structural changes have been supported by investments in pasteurisation and packaging units, as well as by the emergence of local milk-collection cooperatives. In this region, beyond the sale of live animals and meat, camel milk production and processing now contribute

increasingly to the sector's overall turnover. The Ministry of Agriculture reports that the camel milk and dairy derivatives sub-sector alone generates a turnover of around 55 million dirhams, or 11% of the region's total camel-sector revenue, with an added value close to 32 million dirhams (MAPM, 2020). This highlights the specific economic role of milk within the broader camel value chain.

At the transboundary level, the dromedary remains one of the most traded species in Morocco's southern provinces, particularly Laâyoune, Guelmim and Tarfaya. Local experts estimate that several thousand dromedaries are exchanged annually, mainly through informal cross-border channels (FAO, 2019). Regional technical services also report that thousands of camels move each year towards neighbouring countries, with a substantial share passing through unregulated trade routes, limiting statistical traceability (DRAG, Personal communication, 2024). The most active informal routes connect Morocco with Mauritania and Algeria (Kamili *et al,* 2020).

At the national level, camel meat marketing remains limited. This weakness is due to the restricted consumption of camel meat outside Saharan areas, where it is traditionally appreciated, as well as to the lack of structured distribution networks. Consequently, informal slaughtering remains widespread, providing local supplies but bypassing sanitary controls (Ait El Alia *et al,* 2023).

The Moroccan camel value chain therefore relies primarily on the sale of live animals and local or informal slaughtering, while showing increasing potential for processed products. Recent initiatives demonstrate a trend towards diversification: in Boujdour, a camel milk cooperative comprising about 40 members processes nearly 400 000 l/year, whereas in Laâyoune, a pasteurisation unit achieves a capacity of 1.5 tonnes/day of camel milk (ONCA, 2020). Other pilot initiatives have emerged, such as the first camel-milk cheese unit inaugurated in Dakhla in 2023, which has developed a range of innovative cheeses and yoghurts. The creation of the "Fromage de chamelle du Sahara" agricultural label in 2018 (MAPM, 2018) and the Protected Geographical Indication (PGI) "Lait de chamelle du Sahara" in 2017 (OMPIC, 2023; Arrêté du MAPM, 2017) confirm the growing institutional recognition of the sector's potential and its integration into terroir-based market strategies targeting urban and tourism markets.

The range of camel products marketed in Morocco is highly diverse, encompassing fresh, processed and dried meats (Qadid, Loudek, lahmiss, Tichtar, Aflou), dairy products (pasteurised milk, fermented milk 'Lefrik', cheeses, yoghurts), as well as hump fat, which is traditionally used in many dishes and cosmetics and, to a lesser extent, derivative products such as soaps and camel milk-based creams. The main production and processing sites are concentrated in the Saharan provinces , Laâyoune, Boujdour, Dakhla and Guelmim, while consumer markets are expanding towards major urban centres such as Agadir, Marrakech and Casablanca, where specialised retail outlets are beginning to emerge (Amsidder *et al,* 2024; Ait El Alia *et al,* 2023).

## Challenges and constraints of the camel sector in Morocco

Although the dromedary holds a strategic position in Saharan and pre-Saharan regions, both for its ecological role and its contribution to food security and pastoral livelihoods, it has long been marginalised in research and development policies. Institutional efforts have historically prioritised the cattle and sheep sectors, to the detriment of the camel subsector, which explains the relative scarcity of updated data on its production and diseases

**Table 1.** Key nutritional parameters and physicochemical characteristics of Moroccan camel milk.

| Study area (Morocco) | Fat (%) | Lactose (%) | Ash (%) | Acidity (°D | pH | Total solids (%) | Protein (%) | Density | Vitamine C (mg/L) | Source |
|---|---|---|---|---|---|---|---|---|---|---|
| Southern Morocco | - | 3,4 à 5,6 | - | - | 6,55 à 6,65 | - | 3,5 à 4,5 | - | - | Bengoumi & Faye (2015) |
| Southern Morocco | 2,72 | - | 0,87 | 19 | 6,47 | - | 2,55 | 1,026 | - | Alaoui Ismaili *et al* (2019) |
| Dakhla / Errachidia / Fès–Meknès | 3,41 | 4,98 | 0,81 | - | 6,51 | 15 | 3,24 | 1,029 | 27,53 | Bouhaddaoui *et al* (2019) |
| Southern Morocco | 2,65 | 4,05 | 0,83 | 17,7 | 6,61 | 10,8 | 3,25 | 1,032 | - | Kouniba *et al* (2005) |

(Kamili *et al,* 2020). Until recently, the dromedary remained poorly studied by researchers and largely overlooked in development programmes (Faye *et al,* 2014). Limited information is available regarding its production systems, health problems and product quality, compared with other livestock species (Boujenane *et al,* 2019). This situation has resulted in the underdevelopment of the camel sector in Morocco, despite the species' high ecological and economic potential.

The camel farming system is exposed to recurrent droughts, rangeland degradation and overexploitation and a progressive reduction of grazing areas in Draa-Tafilalet region of Morocco caused by irrigated agriculture expansion and urbanization (Boujenane, 2023). Desertification represents a major concern, affecting over 90% of the national territory, particularly in arid and semi-arid zones (Laamouri and Khattabi, 2025). In the area studied by Boujenane (2023), herders reported a progressive reduction in grazing land, shrinking year by year due to the encroachment of cropland over pastoral areas. Institutional responsibilities related to the development and monitoring of the camel sector are fragmented across multiple bodies (ministries, regional agencies, ONSSA, ONCA), with limited coordination, hampering the implementation of targeted and coherent policies (Ibnelbachyr *et al,* 2025). Furthermore, the vast spatial extent over which camel herding systems operate spanning remote arid and semi-arid zones with high mobility of herds across cross-regional corridors greatly complicates surveillance, data collection and timely policy response. This mobility is described as a major logistical and institutional constraint, since tracking herd movements, health status and market flows across such a broad territory exceeds the current coordination capacity of institutional actors (Alary *et al,* 2021; Amsidder *et al,* 2021). Together, these structural and logistical bottlenecks represent significant obstacles to both productivity enhancement and reliable market supply of animals.

Limited access to specialised veterinary services also represents a significant obstacle: camel-specific diseases remain poorly managed, increasing the sector's vulnerability to animal health risks. A study by Drif *et al* (2018) highlighted the presence of viral circulation within camel herds, while Kamili *et al* (2020) and Aït Lbacha *et al* (2017), respectively documented skin diseases and Anaplasmataceae infections, illustrating the lack of specialised veterinary coverage. At the African scale, El-Alfy *et al* (2024) reported an average prevalence of 35 % for Anaplasma infections in dromedaries and 10–12% for Babesia and Theileria, based on data from several North African and Sahelian countries, including Morocco. These findings confirm the high exposure of camel herds to vector-borne diseases, highlighting the urgent need for adapted veterinary monitoring. The productivity of Moroccan camel herds remains modest, with a low average reproductive rate (around one viable calf per three females), reflecting significant demographic and zootechnical constraints (Julien *et al,* 2021).

Camel milk, in particular, continues to face serious health and hygiene challenges. According to Ibnelbachyr *et al* (2025), the physicochemical parameters of the marketed milk are satisfactory; however, its bacteriological quality shows a non-negligible level of contamination, probably due to poor hygiene conditions. This conclusion aligns with other recent studies reporting high bacterial diversity and indicators of poor hygienic practices in samples of raw camel milk collected in southern Morocco (Kadri *et al,* 2021; Ismaili *et al,* 2019). These studies point to insufficient microbiological quality in many camel milk samples. Although the camel value chain holds strong valorisation potential, its development remains constrained by sanitary vulnerabilities, including inadequate collection and processing practices, lack of cold-chain infrastructure and the absence of well-structured supply chains (Ibnelbachyr, *et al,* 2025).

Product valorisation is also hindered by structural constraints, particularly the remoteness of markets, which still limits the sector's full economic potential (Ibnelbachyr *et al,* 2025). Moreover, camel marketing remains largely informal: animals are sold in traditional souks rather than in specialised markets, reducing market visibility and limiting herders' ability to plan production strategies (Kamili *et al,* 2020). The lack of reliable information on trade flows, prices and sales mechanisms constitutes a major barrier to the professionalisation of actors. Recent findings from the camel-milk project confirm the weak structuring of the supply chain. Furthermore, the production system is not fully market-oriented and herders often bring animals to market without prior preparation or price knowledge, mainly to meet immediate financial needs or to cull certain animals (Julien *et al,* 2021).

Globally, the development of camel products has been fuelled by the consumer perception of camel milk as a superfood. This has contributed to the emergence of a niche demand in Morocco,

although retail prices remain very high outside production zones. For example, Amsidder *et al* (2024) reported farm-gate prices ranging from 10 MAD/L to 30 MAD/L in dairy-oriented systems of southern and southeastern Morocco. However, these remain well below the prices of processed camel milk sold in urban markets, where retail observations during the same period indicated prices between 80 and 100 MAD/L. Such high prices may be partly justified by logistical and cold-chain costs and the distance from production zones, yet they remain excessive for most consumers. So, the camel sector in Morocco is constrained by a strong cultural and commercial lock-in, as camel products (milk, meat) are often perceived as functional or medicinal foods, with vendors emphasising their curative value. Reliable data on market prices and outlets remain scarce and most available observations do not originate from peer-reviewed academic studies.

In addition to price barriers, the taste of camel milk, which is less familiar to urban Moroccan consumers accustomed to cow's milk, constitutes another challenge. As a result, camel milk marketing remains largely confined to Saharan regions, where consumers are already familiar with its flavour (Ait El Alia *et al,* 2023). The combination of high prices, limited taste acceptance and restricted availability of processed products continues to hamper market expansion and delay the establishment of structured distribution channels.

**Potential and opportunities of camel production in Morocco**

The camel milk and meat markets are currently experiencing rapid expansion, both in Morocco and internationally. This growth is driven by rising demand from Gulf countries and by the increasing global interest in animal products with high nutritional and functional value (Smits *et al,* 2023; Suliman, 2023). Morocco holds significant strategic advantages owing to its proximity to Sub-Saharan Africa and the Middle East, two regions where the consumption of camel-derived products is expanding rapidly (African Union, 2011). Moreover, the dromedary represents a more stable asset for herders than other livestock species, as its market value is more resilient to droughts and price fluctuations (MAPM, 2020). These characteristics make it an economically secure species, well suited to the changing conditions of Morocco's arid zones.

From an economic and industrial perspective, camel milk processing represents a major opportunity. The adoption of the national standard NM 08.4.300:2016 for pasteurised camel milk marked an important step towards sector structuring (FAO, 2016). Several processing units have been established in southern regions, notably in Boujdour and Laâyoune, producing pasteurised milk, cheese and fermented milk (Ait El Alia *et al,* 2025; ONSSA, 2025). Research and development programmes such as CAMILK and Camel4Milk aim to enhance quality, safety and traceability of camel milk while exploring new market opportunities. These efforts have also enhanced the sector's visibility at both national and international levels. Beyond the participation of camel cooperatives in the International Agricultural Fair of Morocco (SIAM), Morocco has hosted major scientific events that further promoted the camel sector, notably the ISOCARD Conference in Laayoune in 2018 and CAMILDS in 2024, which showcased scientific advances and innovations related to camel production and camel-derived products.

The potential of camel milk extends beyond its nutritional value. It is rich in proteins, unsaturated fatty acids, vitamins and minerals and contains bioactive compounds such as lactoferrin, antioxidant peptides and immunoglobulins, which provide antidiabetic, anti-inflammatory and immune-boosting properties (Ayoub *et al,* 2024; Alhassani *et al,* 2024). These properties open avenues for developing high-value bioproducts, including nutritional supplements, functional foods and natural cosmetics (Boubal *et al,* 2025). The development of such bioproducts represents a promising field of innovation, potentially positioning Morocco as a competitive player in the health and wellness markets, akin to what has been achieved with argan oil.

From a social and cultural perspective, the dromedary retains a central place in the lives of Saharan communities. It remains a source of income, a means of transport, a symbol of prestige and a key element of local heritage (Volpato, 2015). This strong cultural and identity dimension facilitates the transmission of traditional knowledge related to camel breeding and strengthens the sustainability of camel-based systems (Smits *et al,* 2023; Mercha *et al,* 2020). The integration of camels into Saharan tourism, through rides, gastronomy and local products, also offers an opportunity for rural economic diversification (Ibnelbachyr *et al,* 2025).

This evolution is taking place within a favourable policy environment. The Génération Green 2020-2030 national strategy emphasises the modernisation of livestock value chains, traceability

and the valorisation of local products. Since 2010, the Ministry of Agriculture has supported the creation of over fifteen modern units dedicated to the production and processing of camel products (MAPM, 2020). Furthermore, Morocco's accession to the African Continental Free Trade Area (AfCFTA) (African Union, 2022) enhances prospects for regional integration and export to African and Middle Eastern markets. Partnerships with institutions such as the FAO, CIRAD, INRA, IAV Hassan II, ASARI and Phosboukraa Fondation, contribute to strengthening applied research and professionalising the sector. Several initiatives have been supported by the foundation, including the organisation of caravans and forums aimed at improving camel husbandry practices, the implementation of camel health campaigns that have provided care to more than 200 000 of dromedaries across the southern provinces and the development of training and capacity-building programmes for herders and cooperatives, in partnership with regional research and innovation institutions (Phosboucraa Foundation, personal communication, 2025).

Overall, Morocco benefits from a coherent set of opportunities for developing camel production: a species perfectly adapted to its environment, a strong cultural foundation, a favourable regulatory framework and a growing market demand. The main challenge lies in structuring a supply system capable of meeting this demand through better organisation of herders, quality upgrading and continuous technological innovation. If these conditions are met, the Moroccan camel sector could become, in the coming years, a regional model of sustainable development, combining climate adaptation, economic valorisation and preservation of pastoral heritage.

Indeed, in other arid or semi-arid regions comparable to those of Morocco, several camel value chains demonstrate that the modernisation of camel milk production and processing is feasible. In the United Arab Emirates, the Emirates Industry for Camel Milk and Products (EICMP, Camelicious brand) represents one of the most well-documented cases of semi-intensive camel dairy farming. This system is characterised by mechanical milking, stall-based herd management and well-controlled feeding practices (Nagy and Juhász, 2016). Studies conducted within this farm report long lactation periods, good lactation persistence and milk yields significantly higher than those observed in traditional extensive systems, thereby illustrating the dairy potential of the dromedary under controlled conditions (Nagy, 2022).

Furthermore, recent research highlights that camel milk produced in modernised units exhibits nutritional and technological properties that are favourable for diversified industrial valorisation, including the production of milk powders, fermented milks and high value-added functional products (Konuspayeva and Faye, 2022; Seifu, 2023). Although it does not constitute a model that can be directly transposed, the Camelicious experience demonstrates that a value chain structured around intensive farming, processing technologies adapted to the specific properties of camel milk and product diversification can achieve international recognition while remaining embedded in a desert environment. This case therefore provides a relevant point of comparison for discussing potential development pathways of the Moroccan camel sector, provided that any intensification strategy respects pastoral systems, genetic diversity and the socio-cultural functions of the dromedary.

## Conclusion

Morocco has long been recognised as a camel-rearing country and although the national herd remains modest compared with other livestock species, regional trends show considerable variability depending on sources and census data. As elsewhere, official statistics tend to underestimate the true population. Despite its smaller contribution to the national economy compared with cattle or sheep, camel husbandry generates substantial income, primarily through meat sales and increasingly via the marketing of camel milk and derived products. For many pastoral households, the dromedary helps secure and diversify livelihoods, providing a more stable economic resource than other species in arid environments.

Nevertheless, the camel sector faces numerous challenges. These include recurrent drought, rangeland degradation, limited veterinary services, technical knowledge gaps in camel management and restricted market access. Commercialisation remains constrained by inadequate infrastructure and a lack of organised distribution networks.

At the same time, new opportunities are emerging. Increasing aridity reinforces the value of the dromedary as a resilient species. Demand for camel milk and meat is rising on the domestic market and attracting growing international interest. Local and regional initiatives are beginning to promote the valorisation of camel products in food, health and even cosmetic applications. Morocco's strategic

proximity to Europe and the Gulf countries also constitutes a major advantage for the sector's future development.

In this context, an integrated and proactive approach is essential. The sustainable development of the camel sector in Morocco requires a clear and participatory governance framework, capable of bringing together institutional, professional and scientific actors around a shared vision. Strengthening herders' capacities, organising professional associations and establishing structured markets are key priorities for improving the profitability and competitiveness of the sector.

Applied research must also play a leading role, particularly in genetic selection, feed optimisation for arid zones, milk and meat processing and the valorisation of by-products such as leather, fibre and cosmetics. The transfer of knowledge to herders and local entrepreneurs remains vital to link scientific innovation with field practices. Ultimately, the sustainability of Moroccan camel pastoralism will depend on the country's ability to fully integrate the dromedary into its national strategies for livestock development and rural economy enhancement.

**Acknowledgements**

The authors would like to express their sincere gratitude to the Ministry of Agriculture and Maritime Fisheries for its support. They also thank the regional agricultural office of Dakhla–Oued Ed-Dahab, as well as the Agricultural Development Agency of Rabat.

**Conflicts of interest**

The study was carried out without any conflict of interest.

**Statement of authors' contributions**

AH participated in study design and planning; FG collected the data and drafted the first version of the manuscript; BEA, HM, MM and AH, participated in manuscript review. All authors have read and approved the final version of the manuscript and agree to its submission for publication.

## References

African Union. Policy framework for pastoralism in Africa: Securing, protecting and improving the lives, livelihoods and rights of pastoralist communities. African Union Commission, Department of Rural Economy and Agriculture. 2011.

African Union. Africa's Livestock Development Strategy: Enhancing productivity, resilience and market integration. African Union Commission, Department of Rural Economy and Agric. 2022.

Ait El Alia O, Zine-Eddine Y, Kzaiber F, Oussama A and Boutoial K. Towards the improvement of camel milk consumption in Morocco. Small Ruminant Research. 2023; 219:106888. https://doi.org/10.1016/j.smallrumres.2022.106888

Ait Lbacha H, Zouagui Z, Alali S, Rhalem A, Petit E, Ducrotoy MJ, Boulouis H-J and Maillard R. "Candidatus Anaplasma camelii" in one-humped camels (*Camelus dromedarius*) in Morocco: A novel and emerging Anaplasma species? Infectious Diseases of Poverty. 2017; 6(1):1. https://doi.org/10.1186/s40249-016-0216-8

Alaoui Ismaili M, Saidi B, Zahar M, Hamama A and Ezzaier R. Composition and microbial quality of raw camel milk produced in Morocco. Journal of the Saudi Society of Agricultural Sciences. 2019; 18(1):17-21. DOI: 10.1016/j.jssas.2016.12.001.

Alary V, Amsidder L, Araba A, Capote CB, Bedhiaf-Romdhani S, Bensalem W, Boujenane I, Elena C, Letaief N, Faye B, Gaouar SBS, Pastrana CI, Baena SN and Amine L. Social network analysis of the stakeholders involved in the dromedary sector in the Mediterranean region. Sustainability. 2021; 13(21):12127. https://doi.org/10.3390/su132112127

Alhassani WE. Camel milk: Nutritional composition, therapeutic properties, and benefits for human health. Open Veterinary Journal. 2024; 14(12):3164-3180. https://doi.org/10.5455/OVJ.2024.v14.i12.2

Amsidder L, Alary V and Sraïri TM. An empirical approach of past and present mobility management in the desert societies of camel breeders in South Eastern Morocco. Journal of Arid Environments. 2021; 189, Article 104501. https://doi.org/10.1016/j.jaridenv.2021.104501

Amsidder L, Alary V, Duteurtre G and Mnaouer I. The economic contribution of camel-based livestock systems in North-African drylands: The case of East and South Moroccan provinces. Pastoralism: Research, Policy and Practice. 2024; 14:13600. https://doi.org/10.3389/past.2024.13600

Arrêté du ministre de l'Agriculture, de la Pêche maritime, du Développement rural et des Eaux et Forêts n° 2985-17 du 18 safar 1439 (7 novembre 2017) portant reconnaissance du Label Agricole « Fromage de Chamelle du Sahara » et homologation du cahier des charges y afférent. (2016). Bulletin officiel, Ministère de l'Agriculture du Royaume du Maroc.

Azerigyik RA, Owusu-Ansah J, Poku-Boansi M and Agyei FK. Contextualising sustainable transhumant pastoralism: A systematic review. Sustainable Development. 2024; 33(2):2888-2901. https://doi.org/10.1002/sd.3273

Belmahi M, Hanchane M, Mahjoub A, Najjari F, Khayati A and Kessabi R. Sustainability assessment of the main cereals market in Morocco : Evaluating production and import. European Journal of Sustainable Development. 2023; 12(2):135-150. https://doi.org/10.14207/ejsd.2023.v12n2p135

Benayad A, Bikri S, Hindi Z, Lafram A, Belfakira C, Yassif F-Z, El Bilali H and Aboussaleh Y. Transition toward sustainability in the Moroccan food system: Drivers, outcomes, and challenges. World. 2024; 5(3):627-644. https://doi.org/10.3390/world5030032

Bengoumi M and Faye B. Production laitière cameline au Maghreb. Watch Letter n°35.CIHEAM.https://camed.cirad.fr/content/download/4217/31504/version/1/file/Bengoumi%2BFaye%2B2015%2BProduction-laitière%2Bcameline%2Bau-Maghreb.pdf. 2015.

Boubal Z, Khiri S, Ullah N, Lgaz H, Jacobson MG and Elmaaiden E. Valorization of camel bioproducts and wastes: Applications in cosmetics, pharmaceuticals, food, bioenergy, and sustainable economy. Waste and Biomass Valorisation. 2025; 17:1193-1210. https://doi.org/10.1007/s12649-025-02964-8

Bouhaddaoui S, Chentouf M, Boulanouar B, Bister JL and Khalloufi S. Study of the biochemical biodiversity of camel milk collected from different regions of Morocco. Journal of Camel Practice and Research. 2019; 26(1): 35-42.

Boujenane I. Socio-economic characteristics of farmers and constraints to livestock development in the Drâa-Tafilalet region of Morocco. Journal of Animal Science and Veterinary Medicine. 2023; 8(5):179-189. https://doi.org/10.31248/JASVM2023.393

Boujenane I, El Khattaby N, Laghouaouta H, Badaoui B and Piro M. Morphological diversity of female camel (*Camelus dromedarius*) populations in Morocco. Tropical Animal Health and Production. 2019; 51(6):1367-1373. https://doi.org/10.1007/s11250-019-01813-5

Dahan R, Boughlala M, Mrabet R, Laamari A, Balaghi R and Lajouad L. A review of available knowledge on land degradation in Morocco (OASIS Country Report 2). International Center for Agricultural Research in the Dry Areas (ICARDA). 2012; https://hdl.handle.net/20.500.11766/7747

Dahmani Y, Julien L and Sraïri MT. Paramètres démographiques et rentabilité de l'élevage ovin dans la plaine d'agriculture pluviale de la Chaouia, Centre-Ouest du Maroc. Revue d'élevage et de médecine vétérinaire des pays tropicaux. 2025; 78:37645. https://doi.org/10.19182/remvt.37645

Drif K, Venter G, El Harrak M, Fihri OF, Loutfi C, Touil N *et al*. The value of camels as sentinels for bluetongue virus in Morocco. Veterinaria Italiana. 2018; 54(4):343:348. https://doi.org/10.12834/VetIt.1502.8097.1

El Aayadi S, El Hafid B, Maatala N, Bekkar Y, Bounadi I and Julien L. Adaptation des systèmes d'élevage ovin aux changements climatiques : Impacts sur la composante pastorale dans le Haut Atlas central du Maroc. Cahiers Agricultures. 2024; 33:32. https://doi.org/10.1051/cagri/2024029

El Aayadi S, Guedira M, Challioui MK, Boukrouh S and Julien L. Comportement alimentaire des dromadaires sur les parcours du Sud-marocain. Revue d'élevage et de médecine vétérinaire des pays tropicaux. 2025; 78:1-9. https://doi.org/10.19182/remvt.37498

El-Alfy E-S, Abbas I, Saleh S, Elseadawy R, Fereig RM, Rizk MA and Xuan X. Tick-borne pathogens in camels: A systematic review and meta-analysis of the prevalence in dromedaries. Ticks and Tick-Borne Diseases. 2024; 15(1):102268. https://doi.org/10.1016/j.ttbdis.2023.102268

El Hatmi H, Jrad Z, Salhi I, Aguibi A, Nadri A and Khorchani T. Comparison of composition and whey protein fractions of human, camel, donkey, goat and cow milk. Mljekarstvo. 2015; 65(3):159-167. https://doi.org/10.15567/mljekarstvo.2015.0302

Faye B and Bonnet P. Camel sciences and economy in the world: Current situation and perspectives. In Proceedings of the 3rd ISOCARD Conference, Keynote Presentations (pp 2-15). Sultan Qaboos University, Muscat, Oman : ISOCARD. 2012.

Faye B, Jaouad M, Bhrawi K, Senoussi A and Bengoumi M. Élevage camelin en Afrique du Nord : État des lieux et perspectives. Revue d'élevage et de médecine vétérinaire des pays tropicaux. 2014; 67(4), Article 4. https://doi.org/10.19182/remvt.20563

Faye B, Konuspayeva G, Nari A, Koc A and Medina-Diaz E. The camel milk sector in Mediterranean basin. Journal of Camel Practice and Research. 2025; 32(1):1-8. https://doi.org/10.5958/2277-8934.2025.00001.8

Faye B, Senoussi H and Jaouad M. Le dromadaire et l'oasis : Du caravansérail à l'élevage périurbain. Cahiers Agricultures. 2017; 26(1):14001. https://doi.org/10.1051/cagri/2017005

Food and Agriculture Organization of the United Nations. FAO in Africa: Impacts in 2021. 2022; FAO. https://doi.org/10.4060/cb9173en

Food and Agriculture Organization of the United Nations (FAO). Developing sustainable value chains for small-scale livestock producers. FAO. 2019; https://doi.org/10.4060/CA5717EN

Food and Agriculture Organization of the United Nations (FAO). FAOSTAT: Live animals data. FAO. 2023; https://www.fao.org/faostat/en/#data/QA

Ibnelbachyr M, Amer HB, Bouhali BE and Noutfia Y. Investigating the breeding system and economic potential of the peri-urban camel husbandry in southeast Morocco. African and Mediterranean Agricultural Journal. Al Awamia. 2025; 147:139-146. https://doi.org/10.34874/IMIST.PRSM/afrimed-i147.51510

Ismaili M, Saidi B, Zahar M, Hamama A and Ezzaier R. Composition and microbial quality of raw camel milk produced in Morocco. Journal of the Saudi Society of Agricultural Sciences. 2019. https://doi.org/10.1016/j.jssas.2016.12.001

Julien L, Moutik FE, Haloui C, Huguenin J and Sraïri MT. Paramètres démographiques et économie de l'élevage camelin : Une étude au Maroc. Cahiers Agricultures. 2021; 30:1. https://doi.org/10.1051/cagri/2020039

Kadri Z, Spitaels F, Cnockaert M, Amar M, Joossens M and Vandamme P. The bacterial diversity of raw Moroccan camel milk. International Journal of Food Microbiology. 2021; 341:109050. https://doi.org/10.1016/j.ijfoodmicro.2021.109050

Kamili A, Faye B, Saïd Tligui N and Bengoumi M. Typologie des systèmes d'élevage camelins du sud du Maroc. Revue d'élevage et de médecine vétérinaire des pays tropicaux. 2020; 73(2):71-80. https://doi.org/10.19182/remvt.31862

Konuspayeva G and Faye B. Recent advances on camel milk: Nutritional and health benefits and processing implications. AIMS Agriculture and Food. 2022; 7(4):777-804. https://doi.org/10.3934/agrfood.2022046

Kouniba A, Berrada M, Zahar M and Bengoumi M. Composition and heat stability of camel milk produced in Morocco. Journal of Camel Practice and Research. 2005; 12(2):105-110.

Laamouri A and Khattabi A. Estimating the economic cost of land degradation and desertification in Morocco. Land. 2025; 14(4):837. https://doi.org/10.3390/land14040837

Michel J-F, Bengoumi M, Bonnet P, Hidane K, Zro K and Faye B. Typologie des systèmes de production camelins dans la province de Laâyoune, Maroc. Revue d'élevage et de médecine vétérinaire des pays tropicaux. 1997; 50(4):313-323. https://doi.org/10.19182/remvt.9563

Ministère de l'Agriculture, de la Pêche maritime (MAPM). Registre national des indications géographiques et appellations d'origine. Rabat : Royaume du Maroc. 2017.

Ministère de l'Agriculture, de la Pêche Maritime (MAPM). Institutionnel report on camel sector, Rabat, Morocco. 2020.

Ministère de l'Agriculture, de la Pêche Maritime, du Développe2019ment Rural et des Eaux et Forêts. Le Plan Maroc Vert : Bilan et impacts 2008–2018. Rabat, Maroc. https://www.agriculture.gov.ma/sites/default/files/2024-07/20-00529-MA_Plaquette_Bilan%20PMV_VF%286-7-21%29-compress%C3%A9_0.pdf. 2019.

Ministère de l'Agriculture, de la Pêche Maritime (MAPM). Institutionnel report on camel sector, Rabat, Morocco. 2020.

Ministère de l'Agriculture, de la Pêche Maritime (MAPM). Opération de recensement du cheptel national. https://www.agriculture.gov.ma/fr/actualites/operation-de-recensement-du-cheptel-national (Consulté en septembre 2025). 2025.

Muthukumaran MS, Mudgil P, Baba WN, Ayoub MA and Maqsood S. A comprehensive review on health benefits, nutritional composition and processed products of camel milk. Food Reviews International. 2023; 39(6):3080-3116. https://doi.org/10.1080/87559129.2021.2008953

Nagy P. Intensification of camel farming and milk production with special emphasis on animal health, welfare and reproduction. Animal Frontiers. 2022; 12(4):35-44. https://doi.org/10.1093/af/vfac034

Nagy P and Juhász J. Review of present knowledge on machine milking and intensive milk production in dromedary camels and future challenges. Tropical Animal Health and Production. 2016; 48(5):915-926. https://doi.org/10.1007/s11250-016-1051-4

ONSSA. Liste des établissements de lait et produits laitiers agréés et autorisés au Maroc. Office National de Sécurité Sanitaire des Produits Alimentaires (Site official). 2025. https://www.onssa.gov.ma

Office Marocain de la Propriété Industrielle et Commerciale. Indications géographiques et appellations d'origine (OMPIC). 2023. http://www.ompic.ma/fr/content/indications-geographiques-et-appellations-dorigine. (Consulté le 11 Octobre 2025)

Office National du Conseil Agricole (ONCA). L'élevage camelin. Consulté le 12 octobre 2025, à l'adresse. 2020; https://www.onca.gov.ma/fr/blog/lelevage-camelin-0

Piro M, Mabsoute FE, El Khattaby N, Laghouaouta H and Boujenane I. Genetic variability of dromedary camel populations based on microsatellite markers. Animal. 2020; 14(12):2452-2462.

Regional Directorate of Agriculture of Guelmim (RDAG). Personal Communication. 2024.

Seifu E. Camel milk products: Innovations, limitations and opportunities. Food Production, Processing and Nutrition. 2023; 5, Article 15. https://doi.org/10.1186/s43014-023-00143-4

Smits M, Joosten H, Faye B and Burger PA. The flourishing camel milk market and concerns about animal welfare and legislation. Animals. 2023; 13(1):47. https://doi.org/10.3390/ani13010047

Suliman GM. Camel meat as a future promising protein source. Animal Frontiers. 2023; 13(6):53-55. https://doi.org/10.1093/af/vfad065

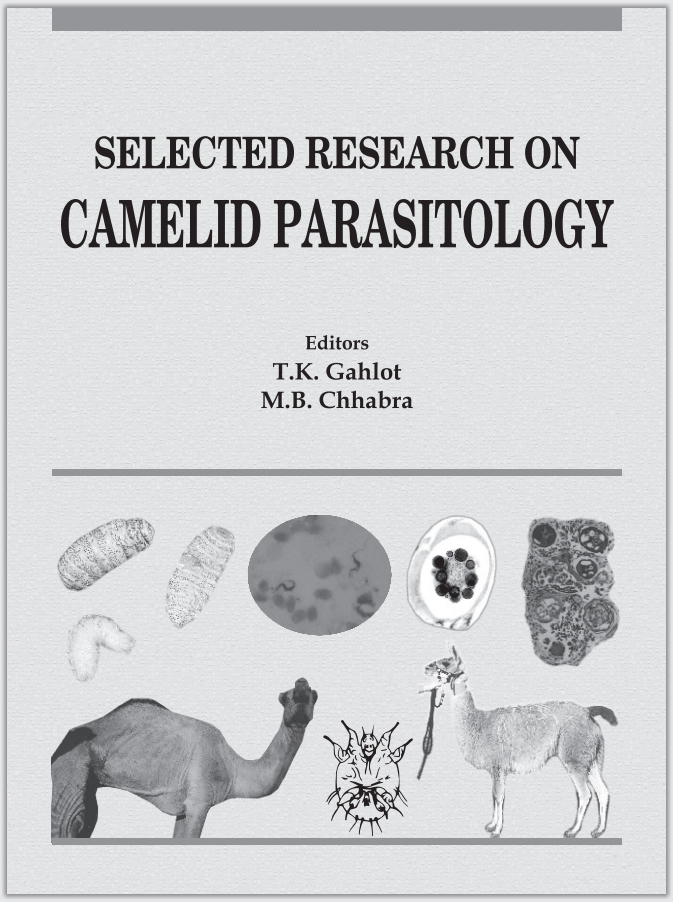
Volpato G, Saleh SM, Di Nardo A and Padoa-Schioppa E. Ethnoveterinary of Sahrawi pastoralists of Western Sahara: Camel diseases and remedies. Journal of Ethnobiology and Ethnomedicine. 2015; 11:54. https://doi.org/10.1186/s13002-015-0039-8

World Bank. Morocco: Water security and drought resilience. World Bank. 2020.

# 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 : 10.5958/2277-8934.2026.00003.3 Vol 33 No 1, p 25-31

# GENERAL ANAESTHESIA IN CAMELS: A SHORT REVIEW

**Tarun Kumar Gahlot[1] and Mahmoud Kandeel[2,3]**

[1]Editor, Journal of Camel Practice and Research and Professor (Retired), Department of Veterinary Surgery and Radiology, College of Veterinary and Animal Sciences, Rajasthan University of Veterinary and Animal Sciences, Bikaner 334001, Rajasthan, INDIA

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

[3]Department of Pharmacology, Faculty of Veterinary Medicine, Kafrelsheikh University, 33516 Kafrelsheikh, Egypt

## ABSTRACT

General anaesthesia is widely used as a method of chemical restraint for various diagnostic procedures as well as for both major and minor surgical interventions. In camelid practice, general anaesthesia may be required for several clinical procedures, including exploratory laparotomy in colicky calves (crias), castration of adult llamas, and surgical exploration of fistulous tracts. However, anaesthetic management of camelids can present challenges because of their unique anatomical and physiological characteristics, stress responses, and airway management considerations. Similar to other domestic species, general anaesthesia in both New World camelids (llamas and alpacas) and Old World camelids (camels) may be induced and maintained using injectable anaesthetic agents, inhalational anaesthetics, or a combination of both. Several drugs including xylazine, guaifenesin, ketamine, thiopental, halothane, and isoflurane have been widely used for sedation and general anaesthesia in camelids. Recent studies have further evaluated the physiological responses and clinical outcomes associated with various anaesthetic protocols, including total intravenous anaesthesia and multimodal analgesia in camelids undergoing surgical procedures. Several classes of drugs are used as premedicants in camelids, including $\alpha_2$-adrenergic agonists, opioids, tranquilizers, and anticholinergic agents. Other $\alpha_2$-adrenergic agonists such as romifidine, medetomidine, and dexmedetomidine have also been investigated for sedation and premedication in camelids. Butorphanol, a mixed agonist–antagonist opioid, is commonly used in camelids as analgesics and are frequently combined with $\alpha_2$-agonists to enhance analgesia and improve sedation. Total intravenous anaesthesia (TIVA) represents a practical and effective alternative to inhalational anaesthesia. Intravenous anaesthetic protocols are commonly used for short to moderate duration procedures such as castration, wound management, orthopedic interventions, and exploratory surgery. Appropriate drug selection, dosage, and monitoring are essential to minimise complications and ensure safe anaesthetic management in camels.

**Key words:** Anticholinergic agents, camelids, general anaesthesia, tranquilizers, $\alpha_2$-adrenergic agonists

Successful anaesthetic management of camelids depends on a thorough understanding of basic anaesthetic principles as well as detailed knowledge of the anatomy and physiology of these species. Appropriate anaesthetic planning is essential to ensure safe induction, maintenance, and recovery in camelids undergoing surgical or diagnostic procedures. Recovery from anaesthesia in camelids is generally smooth, and animals are typically able to stand shortly after tracheal extubation (Fowler, 2010). General anaesthesia is widely used as a method of chemical restraint for various diagnostic procedures as well as for both major and minor surgical interventions. Indeed, the development of modern surgical techniques has been made possible largely through advances in anaesthesia, which remains one of the most important achievements in medical science (Thurmon *et al*, 1996 and Tranquilli *et al*, 2015).

In camelid practice, general anaesthesia may be required for several clinical procedures, including exploratory laparotomy in colicky calves (crias), castration of adult llamas, and surgical exploration of fistulous tracts. However, anaesthetic management of camelids can present challenges because of their unique anatomical and physiological characteristics, stress responses, and airway management considerations. Additionally, camels weighing more than 150 kg body weight often require specialised large-animal anaesthetic equipment for administration of inhalational anaesthetic agents. Therefore, a variety of anaesthetic techniques have been developed and described to ensure safe and effective anaesthesia in camelids.

SEND REPRINT REQUEST TO TARUN KUMAR GAHLOT email: tkcamelvet@yahoo.com

Similar to other domestic species, general anaesthesia in both New World camelids (llamas and alpacas) and Old World camelids (camels) may be induced and maintained using injectable anaesthetic agents, inhalational anaesthetics, or a combination of both. Several drugs including xylazine, guaifenesin, ketamine, thiopental, halothane, and isoflurane have been widely used for sedation and general anaesthesia in camelids. Almubarak (2013) found that intravenous butorphanol produced short-term satisfactory analgesia, coupled with mild sedation and minimal side effects in camels. Recent studies have further evaluated the physiological responses and clinical outcomes associated with various anaesthetic protocols, including total intravenous anaesthesia and multimodal analgesia in camelids undergoing surgical procedures (Goicochea-Vargas *et al*, 2024). Recent research has also evaluated epidural $\alpha_2$-agonists such as romifidine and xylazine, which produce effective sedation and prolonged analgesia in camels undergoing standing surgery (Hamed *et al*, 2025). Dexmedetomidine was established as an effective $\alpha_2$-adrenergic agonist sedative for handling and minor surgical interventions and it was also used in combination with butorphanol and ketamine in camels (Nath *et al*, 2023; Nath *et al*, 2024). Contemporary veterinary literature has also expanded knowledge on camelid anaesthesia and perioperative management through updated clinical texts and practical veterinary guidelines (Niehaus, 2022; Anderson *et al,* 2023). Because camelids possess unique anatomical and physiological features, including compartmentalised stomachs and susceptibility to regurgitation, careful anaesthetic planning is essential.

Therefore, the purpose of this review is to expand the existing body of knowledge by summarising recent advances and relevant literature concerning anaesthetic management in camelids, particularly focusing on llamas, alpacas, and camels.

**Premedication Protocols in Camelids**

Premedication is an important component of balanced anaesthesia in camelids as it helps reduce stress and anxiety, facilitates handling and restraint, and decreases the dose of anaesthetic agents required for induction and maintenance. Appropriate premedication also improves the quality of induction and recovery while providing varying degrees of analgesia and muscle relaxation (Grimm *et al*, 2015). Camelids are generally sensitive to stress and handling; therefore, adequate sedation prior to anaesthesia is recommended to minimise catecholamine release and prevent complications during induction.

Several classes of drugs are used as premedicants in camelids, including $\alpha_2$-adrenergic agonists, opioids, tranquilisers, and anticholinergic agents (Ali *et al*, 1989; Khalil *et al,* 2019; Valverde, 2016) (Fig 1). Among these, $\alpha_2$-adrenergic agonists are most frequently used because of their potent sedative, analgesic, and muscle-relaxant effects. Xylazine is one of the most commonly used sedatives in camelids and has been reported to produce reliable sedation and moderate analgesia (Peshin *et al*, 1980). Typical doses range from 0.1–0.4 mg/kg administered intravenously or intramuscularly, depending on the level of sedation required (Fowler, 2010). However, xylazine may cause dose-dependent cardiovascular depression, including bradycardia and decreased cardiac output, and therefore careful monitoring is required. Xylazine sedation has also been used for liver biopsy in camel (Bucci *et al*, 1982).

Other $\alpha_2$-adrenergic agonists such as romifidine, medetomidine, and dexmedetomidine have also been investigated for sedation and premedication in camelids. These agents generally produce longer and more profound sedation with improved analgesia compared with xylazine. Romifidine has been reported to provide effective sedation with minimal ataxia, while dexmedetomidine has gained increasing attention because of its high selectivity for $\alpha_2$-receptors and its ability to produce reliable sedation and analgesia in camelids (Alsobayil *et al,* 2016; Bani-Ismail, 2016).

Opioid analgesics are frequently combined with $\alpha_2$-agonists to enhance analgesia and improve sedation. Butorphanol, a mixed agonist–antagonist opioid, is commonly used in camelids at doses of 0.02–0.05 mg/kg IV or IM. The combination of xylazine and butorphanol produces synergistic sedative and analgesic effects and is widely used for minor surgical procedures and diagnostic interventions (Anderson *et al,* 2018).

Tranquilisers such as acepromazine may also be used in camelids to reduce anxiety and facilitate handling. Acepromazine produces mild sedation through dopamine receptor blockade and peripheral vasodilation. However, its use should be cautious because it may cause hypotension and prolonged sedation, particularly in debilitated animals. Ali *et al* (1989) used four tranquilisers (propionyl promazine, xylazine, acepromazine and chlorpromazine) in

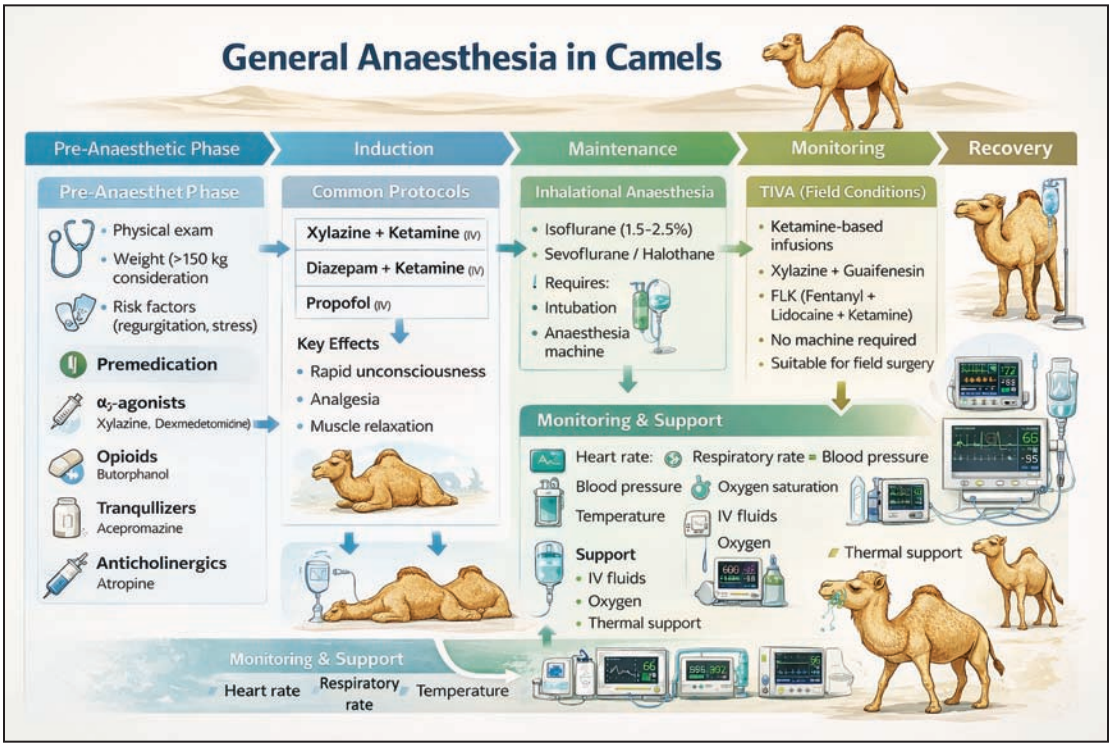



**Fig 1.** Schematic plan of general anaesthesia in camels with different types, phases and protocols.

camels out of which xylazine and propionyl promazine produced significant hyperglycaemia but did not alter plasma concentrations of urea or aspartate aminotransferase.

Anticholinergic drugs such as atropine or glycopyrrolate may be administered as part of the premedication protocol to reduce salivary secretions and prevent vagally mediated bradycardia during anaesthesia. Atropine is typically administered at doses of 0.02 mg/kg intravenously or 0.04 mg/kg intramuscularly when indicated (Muir *et al*, 2020).

Combination protocols such as xylazine–butorphanol or dexmedetomidine–ketamine are commonly used to achieve balanced premedication in camelids (Nath *et al*, 2023; Nath *et al*, 2024). These combinations provide improved sedation, analgesia, and muscle relaxation, resulting in smoother induction and more stable anaesthesia compared with single-drug protocols.

## Maintenance of Anaesthesia in Camels

Maintenance of anaesthesia is the phase during which an adequate depth of anaesthesia is sustained throughout a surgical or diagnostic procedure. In camels, maintenance of anaesthesia may be achieved using inhalational anaesthetic agents or TIVA techniques. The choice of method depends on factors such as availability of equipment, duration of surgery, field conditions, and the health status of the animal. Balanced anaesthesia using combinations of sedatives, analgesics, and anaesthetic agents is generally preferred because it improves anaesthetic stability and minimises adverse effects.

Inhalational anaesthesia is widely used in veterinary practice for maintaining general anaesthesia during surgical procedures in both Old World camelids (dromedary and Bactrian camels) and New World camelids (llamas and alpacas). This technique provides better control of anaesthetic depth, improved oxygenation, and smoother recovery compared with many injectable anaesthetic protocols. Inhalational anaesthesia is particularly useful for prolonged surgical procedures where continuous adjustment of anaesthetic depth is required.

## Principles of Inhalational Anaesthesia

Inhalational anaesthesia involves the administration of volatile anaesthetic agents through the respiratory system using an anaesthetic machine and vaporizer. After induction with injectable anaesthetic agents and successful endotracheal intubation, anaesthesia is maintained by inhalation of volatile anaesthetics mixed with oxygen. The concentration of anaesthetic agent delivered to the patient can be precisely controlled, allowing the anesthetist to rapidly adjust anaesthetic depth during surgery.

In camelids, inhalational anaesthesia requires careful airway management due to anatomical characteristics such as a relatively narrow oral cavity, elongated soft palate, and tendency for laryngeal reflexes. Proper endotracheal intubation is essential to maintain airway patency and prevent aspiration of gastric contents during anaesthesia (Fowler, 2010).

**Inhalational Anaesthetic Agents Used in Camelids**

Inhalational anaesthesia remains an important technique for maintaining general anaesthesia in camels and other camelids. Agents such as isoflurane and sevoflurane provide safe and effective anaesthesia with improved control of anaesthetic depth and smooth recovery. However, careful airway management, monitoring of physiological parameters, and appropriate supportive care are essential to minimise complications during inhalational anaesthesia in camelids.

Inhalational anaesthesia is commonly used for maintaining anaesthesia in camels undergoing prolonged surgical procedures. After induction with injectable anaesthetic agents and successful endotracheal intubation, anaesthesia may be maintained using volatile anaesthetic agents delivered through a large-animal anaesthesia machine (Alsobayil *et al*, 2016).

The most commonly used inhalational anaesthetics in camels include isoflurane, sevoflurane, and halothane. Among these agents, isoflurane is widely preferred due to its rapid onset and recovery characteristics, minimal metabolism, and relatively stable cardiovascular effects. Isoflurane allows easy control of anaesthetic depth and provides smooth recovery following prolonged surgical procedures (Grimm *et al*, 2015).

Studies have demonstrated that maintenance of anaesthesia with isoflurane following xylazine–ketamine induction provides satisfactory anaesthesia with stable physiological parameters in dromedary camels. Isoflurane concentrations typically range between 1.5–2.5% depending on the depth of anaesthesia required (Alsobayil *et al*, 2016).

Sevoflurane has also been investigated as an alternative inhalational anaesthetic because of its rapid induction and recovery properties. However, its use in camelids is less common due to higher cost and limited availability in large-animal veterinary practice.

During inhalational anaesthesia, continuous monitoring of cardiovascular and respiratory parameters is essential. Camels may develop hypoventilation, hypotension, and hypothermia during prolonged anaesthesia. Therefore, supportive measures such as oxygen supplementation, intravenous fluid therapy, and thermal support are recommended (Grimm *et al*, 2015).

**Advantages of Inhalational Anaesthesia**

Inhalational anaesthesia offers several advantages in camelids, i.e.precise control of anaesthetic depth, rapid adjustment of anaesthetic concentration, smooth recovery following prolonged procedures, improved oxygen delivery and ventilation support and reduced cumulative drug effects compared with injectable anaesthesia. These advantages make inhalational anaesthesia particularly suitable for major surgical procedures such as abdominal surgery, orthopedic interventions, and complex diagnostic procedures.

**Physiological Effects and Monitoring**

During inhalational anaesthesia, camelids may experience dose-dependent cardiovascular and respiratory depression. Common physiological effects include reduced respiratory rate, decreased blood pressure, and potential hypoventilation. Therefore, continuous monitoring of vital parameters such as heart rate, respiratory rate, arterial oxygen saturation, blood pressure, and body temperature is essential (Grimm *et al*, 2015). Camelids are also susceptible to hypothermia and regurgitation during prolonged anaesthesia. Appropriate supportive care including thermal support, intravenous fluids, and proper positioning in sternal recumbency can help reduce these risks.

**Clinical Applications**

Inhalational anaesthesia is most commonly used in hospital settings where appropriate anaesthetic equipment is available. It is particularly useful for procedures requiring prolonged anaesthesia, including exploratory laparotomy, orthopedic surgery, and advanced diagnostic procedures. In camelids weighing more than 150 kg, specialised large-animal anaesthesia machines and breathing circuits are often required to maintain adequate ventilation.

**Intravenous Anaesthesia in Camels**

Intravenous anaesthesia is widely used in camels for both field and hospital surgical procedures because it allows rapid induction, adequate analgesia, and reliable muscle relaxation without the need for sophisticated anaesthetic equipment. In many

regions where camel surgery is performed under field conditions, TIVA represents a practical and effective alternative to inhalational anaesthesia. Intravenous anaesthetic protocols are commonly used for short to moderate duration procedures such as castration, wound management, orthopedic interventions, and exploratory surgery.

Several injectable anaesthetic agents and drug combinations have been described for intravenous anaesthesia in camels. Among these agents, ketamine is one of the most commonly used drugs because of its rapid onset, profound analgesic properties, and relatively wide safety margin. Ketamine produces dissociative anaesthesia characterised by analgesia and unconsciousness; however, when used alone it may cause muscle rigidity and inadequate muscle relaxation. Combinations of $\alpha_2$-adrenergic agonists and dissociative anaesthetics such as xylazine–ketamine are widely used for induction of anaesthesia in camels, providing good analgesia and muscle relaxation, while benzodiazepines such as diazepam are sometimes added to improve anaesthetic stability and recovery (White *et al,* 1987; Alsobayil *et al,* 2016; Bani-Ismail, 2016).

The combination of xylazine and ketamine is widely used for induction and short-term intravenous anaesthesia in camels. Xylazine provides sedation, muscle relaxation, and analgesia, while ketamine induces anaesthesia and maintains analgesia during surgical procedures. This combination has been reported to produce satisfactory anaesthesia with acceptable cardiovascular and respiratory parameters in dromedary camels (Fowler, 2010).

Another intravenous anaesthesia technique involves the use of guaifenesin in combination with ketamine and xylazine. Guaifenesin acts as a centrally acting muscle relaxant and enhances the anaesthetic effects of ketamine, allowing smooth induction and maintenance of anaesthesia. This protocol is often used in large animal anaesthesia to maintain balanced anaesthesia for procedures of moderate duration (Muir *et al,* 2020).

More recently, propofol has been investigated for intravenous anaesthesia in camels because of its rapid onset of action and short recovery time. Propofol provides smooth induction and recovery due to its rapid redistribution and metabolism. It may be administered as intermittent bolus injections or as continuous intravenous infusion for maintenance of anaesthesia. However, careful monitoring is required because propofol may cause respiratory depression and hypotension in some animals.

The use of $\alpha_2$-adrenergic agonists such as dexmedetomidine and medetomidine as part of

**Table 1.** Injectable Anaesthetic Protocols Used in Camels.

| Protocol / Drug Combination | Dose (mg/kg) | Route | Purpose | Remarks / Clinical Use |
|---|---|---|---|---|
| Xylazine | 0.1–0.4 | IV / IM | Sedation / Premedication | Produces sedation, analgesia and muscle relaxation; commonly used before induction |
| Ketamine | 2–5 | IV | Induction | Provides dissociative anaesthesia and analgesia; often combined with sedatives |
| Xylazine + Ketamine | Xylazine 0.2–0.4 + Ketamine 2–3 | IV | Induction and short surgical anaesthesia | Widely used protocol producing reliable anaesthesia in camels |
| Xylazine + Ketamine + Guaifenesin | Xylazine 0.1–0.2 + Ketamine 1–2 + Guaifenesin 50–100 | IV infusion | Total Intravenous Anaesthesia (TIVA) | Provides muscle relaxation and balanced anaesthesia for moderate procedures |
| Diazepam + Ketamine | Diazepam 0.1–0.2 + Ketamine 2–4 | IV | Induction | Improves muscle relaxation and prevents ketamine-induced rigidity |
| Propofol | 2–4 | IV | Induction / TIVA | Rapid onset and smooth recovery; may cause respiratory depression |
| Dexmedetomidine + Ketamine | Dexmedetomidine 2–5 µg/kg + Ketamine 2–3 | IV / IM | Sedation and induction | Provides profound sedation and analgesia |
| Romifidine + Ketamine | Romifidine 0.04–0.1 + Ketamine 2–3 | IV | Induction | Produces prolonged sedation with minimal ataxia |
| Medetomidine + Ketamine | Medetomidine 5–10 µg/kg + Ketamine 2–3 | IV / IM | Induction | Balanced anaesthesia with good analgesia |
| Butorphanol + Xylazine | Butorphanol 0.02–0.05 + Xylazine 0.1–0.2 | IV / IM | Premedication | Provides synergistic sedation and analgesia |

intravenous anaesthetic protocols has also been studied in camelids. These agents produce potent sedation, analgesia, and muscle relaxation, and when combined with ketamine or propofol they contribute to balanced anaesthesia with improved analgesic effects and reduced anaesthetic requirements (Bani-Ismail, 2016).

During intravenous anaesthesia, continuous monitoring of physiological parameters including heart rate, respiratory rate, mucous membrane colour, capillary refill time, and body temperature is essential to ensure anaesthetic safety. Supplemental oxygen and intravenous fluid therapy may be required in prolonged procedures to maintain adequate tissue perfusion and oxygenation.

Overall, intravenous anaesthesia remains a practical and effective technique for camel surgery, particularly under field conditions where inhalational anaesthetic equipment may not be available. Appropriate drug selection, dosage, and monitoring are essential to minimise complications and ensure safe anaesthetic management in camels. Injectable anaesthetic protocol used in camels is given in Table 1.

**Maintenance with Total Intravenous Anaesthesia (TIVA)**

TIVA is commonly used in field conditions where inhalational anaesthesia equipment may not be available. In this technique, anaesthesia is maintained using continuous or intermittent intravenous administration of anaesthetic agents.

TIVA was used in llama (*Lama glama*) undergoing unilateral ovariectomy. It was found that pre-anaesthetic - xylazine i/v induction by ketamine and maintenance by fentanyl and ketamine (FLK) (fentanyl + lidocaine + ketamine) by continuous infusion demonstrated better physiological and hemodynamic stability with an acceptable level of surgical anaesthesia (Goicochea-Vargas *et al*, 2024).

Various drug combinations have been used for TIVA in camels, including ketamine, xylazine, guaifenesin, propofol, and benzodiazepines. One commonly described protocol involves the combination of xylazine, ketamine, and guaifenesin, which provides good muscle relaxation and stable anaesthesia for short to moderate surgical procedures (Muir *et al*, 2020).

Ketamine-based infusion protocols are widely used because ketamine produces dissociative anaesthesia and provides effective analgesia. However, when used alone, ketamine may cause muscle rigidity and poor recovery; therefore, it is usually combined with sedatives such as xylazine or diazepam.

Propofol has also been evaluated for maintenance of anaesthesia in camels due to its rapid metabolism and smooth recovery characteristics. Continuous infusion of propofol may provide stable anaesthesia with minimal cumulative effects.

Recent studies have also evaluated the use of $\alpha_2$-adrenergic agonists such as romifidine and dexmedetomidine as part of TIVA protocols to improve analgesia and anaesthetic stability in camels. These combinations provide balanced anaesthesia with reduced doses of induction agents and improved recovery quality (Bani-Ismail, 2016).

Although TIVA is practical for field surgeries, careful monitoring is required to prevent respiratory depression and cardiovascular compromise during prolonged procedures.

**Acknowledgements**

The author used ChatGPT (developed by OpenAI) to assist with language editing, and drafting of preliminary text partially. The author reviewed, edited, and took full responsibility for the final content of the manuscript.

**Funding**

No funding was required for this review paper.

**Data Availability**

The data generated during the study can be requested from the corresponding author.

**Conflict of Interest**

The authors declare no conflict of interest.

**References**

Ali BH, El-Sanhouri AA and Musa BE. Some clinical, haematological and biochemical effects of four tranquilizers in camels (*Camelus dromedarius*). Revue d'Elevage et de Médecine Vétérinaire des Pays Tropicaux. 1989; 42:13-17.

Almubarak AI. Sedative, analgesic and biochemical effects of butorphanol in camels (*Camelus dromedarius*). Journal of Camel Practice and Research. 2013; 20(1):23-27.

Alsobayil FA, Ahmed AF and Eltookhy OS. Isoflurane anaesthesia following xylazine–ketamine administration in camels (*Camelus dromedarius*). Turkish Journal of Veterinary and Animal Sciences. 2016; 40:622–629.

Anderson DE, Miesner MD, Jones ML. Veterinary Techniques in Llamas and Alpacas. Ames: Wiley-Blackwell. 2018.

Bani-Ismail Z. Anaesthetic drugs used in camels: a review. Journal of Camel Practice and Research. 2016; 23:207-211.

Bucci TJ, Botros BA and Gaines JF. Technique for liver biopsy in the dromedary camel using xylazine sedation. Veterinary Record. 1982; 110:200-201.

Fowler ME. Medicine and Surgery of Camelids. 3rd ed. Ames: Wiley-Blackwell. 2010.

Goicochea-Vargas J, Warthon-Medina M, Rondón-Jorge W, Acosta-Pachorro F, Ratto-Fuster M, Silva-Jiménez M, Valderrama-Linares X, Richards I and Salvatierra-Alor M. Physiological and clinical parameters under different protocols of total intravenous anaesthesia in llama (*Lama glama*) undergoing unilateral ovariectomy. Open Veterinary Journal. 2024; 14(11):2950-2959.

Grimm KA, Lamont LA, Tranquilli WJ, Greene SA and Robertson SA. Veterinary Anaesthesia and Analgesia. 5th ed. Ames: Wiley-Blackwell. 2015.

Hamed MA, Zahran IS, Samy A, Fayad E, Katouah HA, Farrag F, Abumandour MMA, Sobhy A, Elolimy AA, Okene IA, Shukry M and Elgioushy M. Comparative antinociceptive and sedative effects of epidural romifidine and xylazine in dromedary camels (*Camelus dromedarius*). BMC Veterinary Research. 2025 May 17; 21(1):353. doi: 10.1186/s12917-025-04706-y. Erratum in: BMC Veterinary Research. 2025 Jul 4; 21(1):435.

Khalil AH, Abd Al-Galil AS, Sabek AA, Zeineldin MM and Abo-Kora SY. Sedative, analgesic, behavioral and clinical effects of intravenous nalbuphine-xylazine combination in camels (*Camelus dromedarius*). The Journal of Veterinary Science. 2019; 20(5):e55.

Muir WW, Hubbell JAE, Bednarski RM and Lerche P. Handbook of Veterinary Anaesthesia. 6th ed. St. Louis: Elsevier. 2020.

Nath K, Bishnoi P, Palecha S and Narnaware SD. Use of dexmedetomidine as sedative in male dromedary camels (*Camelus dromedarius*). Journal of Camel Practice and Research. 2023; 30:131-137.

Nath K, Bishnoi P, Palecha S and Narnaware SD. Clinico-physiohaemodynamic and haemato-biochemical evaluation of dexmedetomidine in combination with butorphanol and ketamine anaesthesia in camels (*Camelus dromedarius*). Journal of Camel Practice and Research. 2024; 31(3):275-283.

Niehaus AJ. Medicine and Surgery of Camelids. Wiley-Blackwell. 2022. ISBN 10: 1119583241 ISBN 13: 9781119583240.

Peshin PK, Nigam JM, Singh SC and Robinson BA. Evaluation of xylazine in camels (*Camelus dromedarius*). Journal of the American Veterinary Medical Association. 1980;177:875-878.

Thurmon JC, Tranquilli WJ, Benson GJ, Lumb and Jones' Veterinary Anaesthesia. 3rd ed. Baltimore: Williams and Wilkins. 1996.

Tranquilli WJ, Thurmon JC, Grimm KA. Lumb and Jones' Veterinary Anaesthesia and Analgesia. 5th ed. Ames: Wiley-Blackwell. 2015.

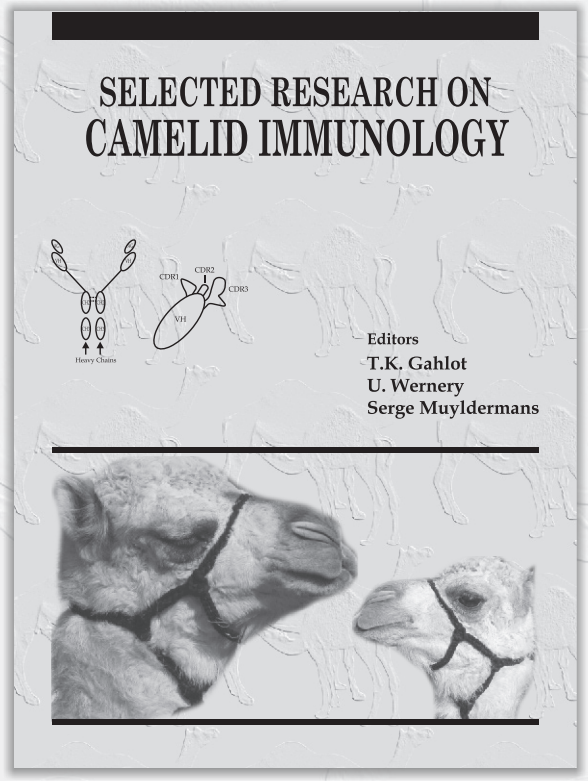
Valverde A. Alpha-2 agonists as analgesics in veterinary medicine. Veterinary Clinics of North America: Food Animal Practice. 2016; 32:351-368.

White RJ, Bali S and Bark H. Xylazine and ketamine anaesthesia in the dromedary camel. The Veterinary Record. 1987; 120:110-113.

# 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 : 10.5958/2277-8934.2026.00004.X Vol 33 No 1, p 33-34

*Short communication*

# BACTERIAL DEFENSE MECHANISM OF THE PLEURAL LUNG CURTAIN IN A DROMEDARY CAMEL

**U Wernery, J Kinne, Christiana Hebel and Marina Joseph**
Central Veterinary Research Laboratory, Dubai, UAE

**ABSTRACT**

A severe overwhelming coccal infection of the lung curtain of an adult dromedary camel led to pneumonia after the lung's defense mechanisms collapsed. This structure is not seen in common domestic animals and very little has been written about this curtain. Some scientists referred to them as "fringes" or "extensions", little is known about these enigmatic structures. Present report describes herewith a severe haemorrhagic and lymphoblastic coccal infection of the lung curtain, leading to pneumonia.

**Key words:** Dromedary camel, lung curtain, phagocytic cells, visceral pleura

A severe overwhelming coccal infection of the lung curtain of an adult dromedary camel led to pneumonia after the lung's defense mechanisms collapsed.

The pleural lung curtain is a defense structure that protects the lungs from infection. Described as a specific camelid feature, it has also been observed in the giraffe, another species with a long neck (Anat Rec, 293: 1776 – 1786). This structure is not seen in common domestic animals and very little has been written about this curtain. Although these structures were noted by Al-Tarazi (2001) and Al-Hamad and Khamas (2002), who referred to them as "fringes" or "extensions", little is known about them and the descriptions by these authors were somewhat superficial. Serious investigations, however were undertaken by Buzzell *et al* (2010) using light and electron microscopy to gain some insight into the functions of these enigmatic structures. The authors describe herewith a severe haemorrhagic and lymphoblastic coccal infection of the lung curtain, leading to pneumonia.

## Materials and Methods

An adult female dromedary camel was admitted to the Dubai Camel Hospital at the beginning of December 2025 with high fever, complete anorexia and high white blood cell count. Despite treatment, it died 3 days later and was sent to the Central Veterinary Research Laboratory for necropsy. The camel weighed 451 kg and was in fresh and good condition.

## Pathology

The camel was dissected at CVRL, where gross pathology alterations were recorded and samples for histology and microbiology were taken from each organ and tested using routine methods.

## Results

The lung showed a severe diffuse pulmonary emphysema, severe oedema and consolidation of both lobes. Additionally, both lobes displayed multifocal to coalescing white nodules, measuring 3 to 4 mm in diameter and exhibiting a firm appearance. Histologically, numerous peribronchiolar and perivascular lymphoblastic infiltrates were observed, corresponding to the white nodules seen in gross pathology.

The lung curtain was enlarged and severely haemorrhagic (Fig 1). For comparison, lung curtain of a healthy adult dromedary camel is shown in Fig 2.

## Discussion

Pneumonia in adult dromedaries is rare. When it occurs, it is usually in conjunction with systemic disease rahter than as an independent illness, and it primarily affects young dromedaries (Wernery

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

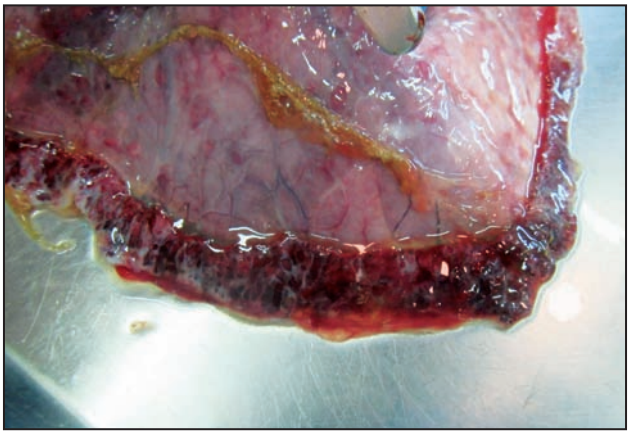


**Fig 1.** Severely thickened and haemorrhagic lung curtain caused by *Streptococcus faecalis* infection.

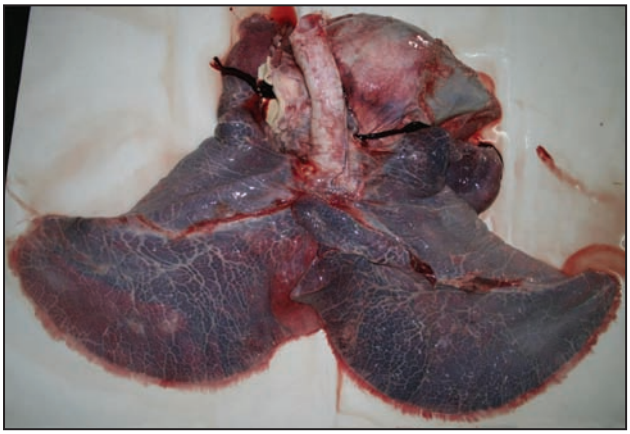


**Fig 2.** Dromedary camel lung, showing the pleural curtain along the basal lung margins of a healthy camel.

*et al*, 2014). The pleural lung curtain is a defence structure that protects the lung from infection, which may be the main reason adult dromedary camels and giraffes rarely develop pneumonia (Letzner, 1987). The position of the pleural curtain in the costophrenic recess, combined with the presence of multiple perivascular lymphoblastic infiltrates and phagocytic cells, suggests that the pleural curtain stirs, samples and cleans the pleural fluid during inhalation and exhalation. It acts much like a "windscreen wiper". However, when the curtain defense mechanism is overwhelmed - as in this rare case by a barrage of *Streptococcus faecalis* - the systems collapse. This is evidenced by the thickening and haemorrhagic state of the pleural curtain. In this case, the bacteria sucessfully entered the lung, leading to the development of emphysema and oedema. Both lung lobes contained multifocal to coalescing white, firm nodules (lymphoblastic infiltrates), which were also observed in the lung curtain. *Streptococcus faecalis* was isolated from the lung tissue in high numbers.


## Acknowledgements

Thanks to Dr. Ahsan Ul Haq from Dubai Camel Hospital who submitted the carcass to CVRL.


## Ethical Statement

This study was done according to the approval of Ethical Committee of CVRL, Dubai.

## Data Availability

The data generated during the study can be requested from the corresponding author.

## Conflict of Interest

The authors declare no conflict of interest.

## References


Al - Hamad WH and WA Khamas. Anatomical and histological features of pulmonary tissue of the one-humped camel (*Camelus dromedarius*). Journal of Camel Practice and Research. 2002; 9:31-36.

Al - Tarazi YH. Bacteriological and pethological study on pneumonia in the one-humped camel (*Camelus dromedarius*) in Jordan. Revue d'Elevage et de Medecine Veterinaire des Pays Tropicaux. 2001; 54:93-97.

Buzzell GR, J Kinne, Saeed Tariq and U Wernery. The pleural curtain of the camel *Camelus dromedarius*. The Anatomical Record. 2010; 293:1776-1786.

Letzner G. Ein Beitrag zur Immobilisation, Physiologic und Pathologic der Giraffen. Dissertation, Tierärzte. Hochschule Hannover, Germany. 1987.

Wernery U, J Kinne and RK Schuster. Camelid Infectious Disorders. OIE Book, Respiratory System. 2014; pp 113-126.

DOI : 10.5958/2277-8934.2026.00005.6 Vol 33 No 1, p 35-40

# AN ASSESSMENT OF CAMEL MARKING AND CLAN IDENTIFICATION IN THE AFAR REGIONAL STATE, ETHIOPIA: THE CASE OF BERHALE WOREDA

**Kassahun Ahmed Seid**
Department of Animal Sciences, Wollo University, P.O.Box 1145, Dessie campus, Dessie, Ethiopia

## ABSTRACT

This study evaluated the indigenous protocols for camel recognition currently practiced within the Berhale district of Ethiopia's Afar Territory. By surveying 90 pastoralist units through a cross-sectional lens, the study established that phenotypic marking represents a ubiquitous norm, functioning as the cornerstone of local herd administration. Participants detailed how each primary lineage and sub-group locally designated as gosa deploys specific heraldic motifs on designated anatomical zones to validate communal ownership and deter illicit acquisition. Thermal cauterisation (fire-branding) was identified as the prevailing modality, generally administered once calves have achieved post-weaning maturity. Our spatial assessment of these branding sites indicated that a 60% majority (n=54) favours a dual-marking strategy involving the cervical and appendicular regions. Additionally, a focused neck-branding approach was recorded for 32.2% of the cohort (n=29). Peripheral identifiers were also noted on the cranial surface, pinnae, and occasionally the ventral region. The data suggests that fire-branding constitutes the fundamental ethno-legal framework for certifying property rights and fortifying the security of dromedary populations throughout Berhale Woreda.

**Key words:** Afar territory, cautery marks, dromedary recognition, herding strategies, Northeast Ethiopia

The camel transcends its role as a commodity, for the inhabitants of Ethiopia's arid lowlands, serving as a vital safeguard against total environmental collapse (Bekele *et al,* 2002; updated by Tefera, 2024).

In the contemporary agrarian landscape, animal labelling has evolved from ancestral tribal signatures into complex mechanisms for international biosecurity and trade participation. While historical classifications by Landais (2001) categorised marking as either ephemeral or indelible, current regulatory environment demand verifiable provenance to unlock global markets. As of 2025, the Ethiopian Ministry of Agriculture, in alliance with the African Union, has emphasised the Livestock Identification and Traceability System (LITS) to synchronise local practices with international phytosanitary protocols (MoA, 2025b). These digitised records are now fundamental for tracking disease outbreaks and managing hereditary breeding data.

Despite the proliferation of electronic alternatives, fire-branding persists as a cornerstone of Afar heritage. In Ethiopia's rangelands, these ocular symbols act as a decentralised registry to mitigate theft and simplify the retrieval of lost stock (Kassahun, 2011). However, this customary practice faces increasing scrutiny; by 2026, the World Organisation for Animal Health has intensified its advocacy for non-invasive labelling to reduce physiological trauma and preserve the commercial quality of hides. Typically, these markings are applied to yearlings, balancing biological maturity with the social imperative of property designation.

Currently, Berhale Woreda suffers from a deficit of formal documentation regarding its specific branding aesthetics and technical variations. Evaluating these ancestral protocols is crucial for safeguarding intangible cultural heritage and identifying strategies to minimise the permanent scarring that diminishes the export value of camel leather (MoA, 2025a). Consequently, this study was designed to chart the logic of traditional identification among Berhale's herders, aiming to align ancient cultural markers with the rigorous demands of the modern livestock economy.

## Materials and Methods

### *Spatial and environmental context*

The study was situated within the Berhale district, a prominent pastoral hub in the Afar Regional

SEND REPRINT REQUEST TO KASSAHUN AHMED SEID email: kassahunahmed220@gmail.com

State of Ethiopia. This territory is geographically defined by the coordinates 13° 12′ to 14° 15′ North and 9° 54′ to 41° 06′ East. Positioned in Ethiopia's northeastern sector, Berhale is located approximately 647 km from the regional centre of Semera and 908 km from the national capital, Addis Ababa. The district is characterised by its proximity to the Danakil (Dallul) Depression, an area noted for its extreme environmental conditions. The administrative boundaries of Berhale include the Eritrean border to the northeast, Dallul to the north, the Tigray Region to the west, and the districts of Abala and Afdera to the south. With a mean altitude of 621 meters above sea level, the district's ecology is uniquely suited for dromedaries. Recent data (Afar BoFED, 2024) indicates that camel population in this region significantly exceed those of cattle and small ruminants, cementing Berhale's status as a vital location for camel-centric ethno-veterinary research.

### *Research design and sampling protocol*

A multi-stage sampling strategy was employed to ensure both data representativeness and logistical feasibility. Out of the nine administrative sub-units (kebeles) in the district, five were selected through purposive sampling, based on camel density and geographic accessibility. Within these selected kebeles, a randomised selection of households per unit was conducted, total 90 participating households. Primary data acquisition involved a combination of direct field observations and the administration of a systematic survey instrument. This approach allowed for the triangulation of self-reported identification practices with real-time evidence of branding marks observed on the livestock.

### *Data processing and quantitative analysis*

The collected survey responses were categorised and coded for systematic evaluation. Quantitative data management was performed using contemporary versions of the Statistical Package for Social Sciences (SPSS). To interpret the field findings, the author utilised descriptive statistical models, focusing on the calculation of relative frequencies, percentages, and measures of central tendency. These metrics were employed to map the prevalence and spatial distribution of camel branding protocols across the study area.

## Results and Discussion

### *Prevalence and methodology of traditional marking*

The survey revealed a universal adherence to camel marking, with 100% of the sampled households confirming the utilisation of traditional identification systems (Table 1). The predominant technique identified across the Berhale Woreda is thermal cauterisation (hot-iron branding). This procedure is strategically performed during the post-weaning developmental stage, ensuring the calves have achieved sufficient physiological maturity to undergo the branding process. These results align with broader regional trends in the Afar state, where branding serves as both a cultural signature and a practical deterrent against livestock raiding (Afar Bureau of Agriculture, 2024; Mohammed *et al,* 2025).

### *Anatomical distribution of identity marks*

Analysis of the branding locations demonstrated a clear preference for specific body regions to ensure visibility and ease of recognition. As illustrated in the data, the majority of respondents 60% (n=54) apply identifiers to both the cervical (neck) and appendicular (leg) regions. A significant secondary group, comprising 32.2% (n=29) of the households, utilises the neck area exclusively. While these areas represent the standard, a small minority of pastoralists utilise alternative sites, including the facial region, the ears, and the ventral (stomach) surface, though the latter remains an exceptional case (Table 1).

**Table 1.** Distribution of branding sites and selection rationale among pastoralists (N=90).

| Variable Category | Frequency (n) | Percentage (%) |
|---|---|---|
| Prevalence and Methodology of Traditional Marking | 90 | 100 |
| **Anatomical Site of Identification** | | |
| Combined Cervical and Appendicular (Neck and Leg) | 54 | 60.0 |
| Primary Cervical Only (Neck) | 29 | 32.2 |
| Cervical and Ventral (Neck and Stomach) | 3 | 3.3 |
| Primary Appendicular Only (Leg) | 2 | 2.2 |
| Multi-site (Neck, Leg, and Ear) | 2 | 2.2 |
| **Rationale for Site Selection** | | |
| Traditional Clan Lineage (Gosa) Requirements | 67 | 74.4 |
| Visual Prominence/Ease of Recognition | 19 | 21.1 |
| Concurrent Cultural and Visibility Factors | 4 | 4.4 |

N = number of respondents

This distribution pattern suggests a sophisticated indigenous knowledge system where

mark placement is dictated by the need for rapid identification in communal grazing lands (Tura *et al,* 2024). However, recent technical assessments indicate that such extensive branding on the neck and legs significantly degrades the industrial grade of the hide. Specifically, branding in these high-value zones can reduce the usable surface area of the leather by up to 25%, impacting the overall export market value (Ethiopian Leather Industry Development Institute [ELIDI], 2025). Consequently, there is an urgent need for "localised marking alternatives" that balance traditional lineage visibility with the preservation of hide integrity for the global leather value chain (Ministry of Industry, 2025).

### *Ethno-taxonomy of clan-based branding systems*

The camel identification system in the Berhale Woreda operates through a sophisticated ethno-taxonomy, where specific branding motifs are inextricably linked to lineage identity (Table 2). The study observed that cervical (neck) branding is the most prevalent anatomical site for primary clan markers. For instance, lineages such as the Dahimila and Barkol utilise variations of vertical bar motifs, locally referred to as *Dal*. These symbols range from simple parallel bars to more complex arrangements, such as the *Dal kee dalfida* used by the Barkol or the *Dal kee kulfi* a vertical bar with distal curves—favoured by the *Daar bura*. The *Dahimila asela* further distinguish their stock by integrating cruciform elements (*Ambetiba*) alongside the standard vertical bars. Beyond the cervical region, other anatomical sites serve as secondary identifiers for specific sub-lineages. The *Mandita* and *Seka* clans prefer *appendicular* (*leg* and *thigh*) marking, utilising undulating or wave-like motifs known as *Dal or Selef nemaye*. In more distinct cases, the *Gediinto* utilise *cranio-facial* and *auricular* (*face* and *ear*) sites for their sigmoidal markers (*Gudinto kulfi*), while the Egemaqumer apply divergent strokes with a central focal point (*afdida*) on the neck. These indigenous branding protocols represent more than mere property marks; they are a vital component of the Afar customary law system. By providing immediate visual proof of origin, these marks facilitate community-based protection against theft and environmental predation. According to recent assessments by the Ethiopian Ministry of Agriculture (2025b), documenting these traditional *gosa* symbols is increasingly important for the National Livestock Traceability System (ET-LITS). As of 2026, there is a strategic move to digitise these indigenous "heraldic" marks, allowing pastoralists in the Berhale district to maintain their cultural heritage while participating in formal, high-value export markets that require verified proof of origin (Afar BoFED, 2024; Tefera *et al,* 2025).

### *The hierarchy of identifiers: main clans and sub-lineages*

The identification system in the Afar Region reflects the complex socio-political structure of the community. Every primary ethnic lineage, or gosa, possesses a unique signature and a designated anatomical site for mark placement (Table 2). This system operates through a hierarchical branding protocol:

- **Primary Markers:** Sub-clans typically adopt the ancestral symbol of the main gosa.
- **Secondary Differentiation:** To distinguish sub-lineages, additional specific markers are applied in varying orientations or adjacent sites.
- **Individual Identifiers:** In specific instances, owners may append a tertiary personal mark to denote individual property within the broader communal herd.

This multi-layered approach ensures that any member of the community can readily identify a camel's lineage, thereby acting as a collective defense against predatory threats and unauthorised appropriation. The findings regarding dual clan and individual marking systems corroborate earlier foundational studies by Wilson (1998) and Ahmed (2002), who noted the importance of dual-brand ownership.

### *Dextral preference in marking and management*

A significant finding of this study is the consistent dextral (right-side) orientation for both branding and general animal handling. Pastoralists in the Berhale district exhibit a strong preference for the right side of the dromedary, not only for the application of identity markers but also as the standard side for milking and routine husbandry (Gebremariam *et al,* 2024). This lateral consistency facilitates easier management in communal kraals and ensures that symbols are immediately recognisable during daily interactions (Afar Bureau of Agriculture [BoA], 2024). However, these traditional "right-side" marking habits are now being integrated into the National Livestock Identification and Traceability System (LITS). By aligning digital ear tags with the traditionally branded right side, regional agricultural offices in the Afar State are bridging the gap between indigenous knowledge and international export

**Fig 1.** Illustration of traditional thermal markers situated on the ventral (abdominal) region of the dromedary.

**Fig 2.** Distribution of traditional identity markers situated on the pelvic limb and femoral (round) regions of the dromedary.

**Fig 3.** Visual representation of indigenous thermal branding applied to the cervical (neck) region of the dromedary.

**Fig 4.** Field demonstration by a local pastoralist depicting traditional clan motifs rendered on the ground surface.

requirements (Ministry of Agriculture [MoA], 2025b). This harmonisation is critical for ensuring that individual animal data correlates with clan-level ownership marks, a prerequisite for the 2026 Horn of Africa Livestock Trade Protocol (African Union-IBAR, 2025).

## Conclusion and strategic implications

This investigation underscores that indigenous camel marking systems in the Berhale Woreda are foundational to the socio-cultural and economic stability of Afar pastoralists. A comprehensive analysis of these traditional identification protocols provides more than just ethnographic data; it offers a critical framework for modernising the livestock sector. By integrating this indigenous knowledge with contemporary veterinary standards, policymakers can develop targeted interventions that mitigate the adverse effects of thermal branding on animal physiology and hide integrity. Furthermore, optimising these identification strategies is essential for enhancing the marketability of camel by-products. Reducing the prevalence of deep-tissue scarring through refined marking techniques will directly improve the industrial grade of camel leather, thereby increasing the economic returns for local herders. Ultimately, bridging the gap between traditional gosa recognition systems and modern traceability frameworks will catalyse more resilient camel production cycles and strengthen the livelihood

**Table 2.** Taxonomic Inventory of Traditional Identity Markers and Anatomical Branding Sites in Berhale woreda.

| Lineage Designation (Gosa) | Primary Anatomical Site | Geometric Motif Description | Symbol | Vernacular Designation |
|---|---|---|---|---|
| (Afar language) | | | | |
| Dahimila | Cervical (Neck) | Parallel vertical bars | \| \| | Dal |
| Barkol | Cervical (Neck) | Discontinuous vertical strokes | \| , \| | Dal kee dalfida |
| Daar bura | Cervical (Neck) | Vertical bars with distal curves | u\| \| or \| \|u | Dal kee kulfi |
| Dahimila asela | Cervical (Neck) | Cruciform-integrated bars | +\| \| or \| \|× | Dal kee Ambetiba |
| Mandita | Appendicular (Leg) | Horizontal wave/ undulation | ≈ | Dal |
| Damohoyta | Cervical (Neck) | Inverted semi-circular arch | ∩ | Ogoyta |
| Seka | Femoral/Pelvic Limb (Thigh) | Double undulating stroke | ≈ | Selef nemaye |
| Gediinto | Cranio-facial/Auricular Face/ear/ | Hooked or sigmoidal mark | ? | Gudinto kulfi |
| Egemaqumer | Cervical (Neck) | Divergent strokes with central point | / ▪ \ | Egma oumer/Dal kee afdida |
| Ganento | Cervical (Neck) | Triple diagonal slash | / // | Abur sidhu |

security of pastoralist communities in the Afar Regional State.

## Declarations

### Availability of Data and Materials

To maintain academic transparency and accountability, the primary datasets generated and analysed during this study are available from the corresponding author upon reasonable request.


### Funding

This research was entirely self-funded. The author received no specific grants or financial support from public, commercial, or non-profit funding agencies.


### Ethics Approval

This study was executed following the established ethical protocols for agricultural and social research. All participating pastoralist households provided informed verbal consent after being briefed on the study's purpose. Participants were assured of complete anonymity and the confidentiality of their responses prior to the data collection process.

### Manuscript Status and Originality

The author certifies that this manuscript is an original work that has not been published elsewhere, in part or in full, and is not currently under consideration by any other journal. The author agrees to maintain exclusivity with JCPR until the editorial review process is finalised.

### Conflict of Interest

The author declares that the research was conducted without any commercial, financial, or personal affiliations that could represent a potential conflict of interest. No external influence or funding impacted the objectivity of the presented findings.

### Author's Contribution

The author was solely responsible for the end-to-end execution of the project, including the initial conceptualisation, study design, and field data acquisition. Additionally, the author performed all statistical analyses, interpreted the results, and was responsible for the drafting, critical revision, and final approval of the manuscript.


### Acknowledgements

The author expresses sincere gratitude to the pastoralist communities of Berhale Woreda for their remarkable hospitality and cooperation. Their willingness to share indigenous knowledge was fundamental to this study. Furthermore, the author thanks the local administrative leaders and community elders in the Afar Region for the logistical guidance that made access to remote sampling areas possible.


## References


Afar Bureau of Agriculture. Annual Progress Report on Livestock Management and Veterinary Services in the Afar Regional State. Semera, Ethiopia: Regional Government Press. 2024.

Afar Bureau of Agriculture [BoA]. Technical Guidelines for

Communal Husbandry and Lateral Handling Protocols in Camelid Populations. Semera, Ethiopia: Regional Government Press. 2024.

Afar Bureau of Finance and Economic Development [BoFED]. Regional Statistical Abstract and Economic Indicators. Semera, Ethiopia: BoFED Data Center. 2024.

African Union-IBAR. The 2026 Horn of Africa Livestock Trade Protocol: Harmonising Traditional Ownership with Regional Market Standards. Nairobi, Kenya: African Union Interafrican Bureau for Animal Resources. 2025.

Ahmed MS. Traditional Knowledge and Management of Camels by the Afar Pastoralists. Addis Ababa, Ethiopia: International Livestock Research Institute (ILRI). 2002.

Bekele T, Lunde T and Hareide BK. The role of camels in the food security of pastoralists in the Afar region of Ethiopia. Journal of Arid Environments. 2002; 50(2):201-210.

Central Statistical Agency [CSA]. Agricultural Sample Survey: Report on Livestock and Livestock Characteristics (Private Peasant Holdings). Statistical Bulletin, Addis Ababa, Ethiopia. 2025.

Ethiopian Leather Industry Development Institute [ELIDI]. Technical Report: The Impact of Branding and Ectoparasites on the Industrial Grade of Camel Hides in Ethiopia. Addis Ababa: Ministry of Industry. 2025.

Gebremariam T, Hailu G and Negash S. Behavioral and lateral preferences in dromedary management: A study of dextral handling in northern Ethiopia. Journal of Veterinary Behaviour and Ethology. 2024; 19(3):112-127.

Kassahun A. Traditional Camel Branding and Identification Systems in North-Eastern Ethiopia. M.Sc. Thesis, Haramaya University, Ethiopia. 2011.

Landais E. Marking and identification of livestock: A review of traditional and modern methods. Revue Scientifique et Technique (International Office of Epizootics). 2001; 20(2):463-479.

Ministry of Agriculture [MoA]. Integration of Digital Traceability Systems with Indigenous Branding Practices: A Roadmap for the Afar State. Addis Ababa: Federal Democratic Republic of Ethiopia. 2025a.

Ministry of Agriculture [MoA]. National Livestock Identification and Traceability System (LITS): Strategic Implementation Guidelines. Addis Ababa: Federal Democratic Republic of Ethiopia. 2025b.

Ministry of Industry. Sectoral Strategy for the Enhancement of the Global Leather Value Chain. Federal Democratic Republic of Ethiopia. 2025b.

Mohammed A, Tura I and Yusuf M. Indigenous livestock branding as a tool for security and lineage identity in Afar rangelands. Ethiopian Journal of Animal Production. 2025; 25(1):44-58.

Tefera M. Camels in Ethiopia: Biology, Management, and Economic Significance. 2nd Edition. Addis Ababa University Press. 2024.

Tefera M, Ahmed K and Haile S. Digitizing the Gosa: Integrating traditional Afar heraldry into national traceability registries. Journal of Camel Science and Technology. 2025; 13(2):89-104.

Tura I, Kuria SG and Walaga HK. Spatial distribution of branding marks and their recognition in communal grazing systems of the Horn of Africa. Pastoralism: Research, Policy and Practice. 2024; 14(1):12-25.

Wilson RT. The Tropical Agriculturalist: Camels. London: Macmillan Publishers/CTA. 1998.

DOI : 10.5958/2277-8934.2026.00006.2 Vol 33 No 1, p 41-49

# DERMATOLOGIC AND FAECAL HELMINTHIC EGG INVESTIGATION IN DROMEDARY CAMELS AT A LIVESTOCK MARKET IN DOHA, QATAR

**Naod Thomas Masebo[1], Barbara Padalino[1,2], Jessica P. Johnson[3], Midori G. Asakawa[4] and Masa-aki Oikawa[3]**

[1]Department of Agricultural and Food Sciences (DISTAL), University of Bologna, Viale G. Fanin 44, 40127 Bologna, Italy.
[2]Faculty of Science and Engineering, Southern Cross University, Lismore, Australia
[3]Equine Veterinary Medical Centre, P.O. Box 90055, Qatar Foundation, Doha, Qatar
[4]Veterinary Specialists Emergency Centre, Postcode: 330-0823, 8151, Kawaguchi, Saitama, Japan

## ABSTRACT

This study was aimed to assess cutaneous conditions and gastrointestinal (GI) parasitism of camels kept in a livestock market in Doha, Qatar. Fifteen animals showing skin lesions were examined through macroscopic inspection, adhesive tape impression cytology (ATIC) and superficial skin scraping cytology (SSSC). Fresh faeces from nine camels were tested using Mini-FLOTAC. Alopecia with or without hyperpigmentation and crusting was recorded in 13 animals, nodules/macules in one and mixed lesions in one. The skin lesions were mainly found on the neck, shoulders, abdomen and hump. On ATIC, larval (seed) ticks were detected in two animals; hyperkeratosis in eight; and exudative dermatitis with inflammatory cells in three. On SSSC, hair shaft arthroconidia consistent with dermatophytosis were observed in five camels, accompanied by hair shaft thickening, cuticular lifting or loss, trichoptilosis and altered melanin granules; yeast-like bodies were found in four cases. Background scale/scab material was common; lesion severity was mild in four cases and severe in 11. No inflammatory cells were detected on SSSC. Mini-FLOTAC identified non-sporulated oocysts of *Eimeria cameli* and *dromedari* in three faecal samples; no nematode or cestode eggs were detected. These findings highlight heterogeneous but predominantly superficial dermatologic processes and protozoal GI parasitism in market camels. These preliminary data prove that skin disorders are a welfare concern and are useful to suggest recommendations to improve the health and welfare of camels kept on markets. Further and larger studies are needed to confirm our findings.

**Key words:** Dermatologic examination, dermatophytosis, dromedary camels, faecal egg examination, qatar, skin diseases, skin scraping, tape impression

Skin disorders due or not to infectious agents are considered common among dromedary camels kept in intensive farming (Menchetti *et al,* 2021) and have been included as an animal-based welfare indicator in welfare protocols for this species (Menchetti *et al,* 2021; Padalino and Menchetti, 2021). Additionally, other most common skin diseases reported in camels include ringworm, contagious skin necrosis (*Dermatophilus congolensis*), and sarcoptic mange (*Sarcoptes scabiei var. cameli*), (Almuzaini *et al,* 2016; Kinne and Wernery, 2003; Khelifi-Ouchene *et al,* 2020; Jain *et al,* 2005).

A recent systematic review has shown that epidemiological data on dromedary camel skin infections and parasitic diseases are limited, with publications largely from Egypt, Tunisia, Morocco, Algeria, the United Arab Emirates (UAE) and Saudi Arabia (El-Alfy *et al,* 2024). Some of the skin infections surveys are the following; Kamili *et al* (2019) reported in Morocco an incidence of 52% and 30% mite and dermatophyte infections, respectively; Almuzaini *et al* (2016) reported 11.5% dermatophytosis in Saudi Arabia; Khelifi-Ouchene *et al* (2020) reported 57.1%, 28% and 16.5% of ticks, scabies and ringworms infested camels, respectively, in Algeria; Ahmed *et al* (2020) in Egypt reported 47.6% sarcoptic mange in dromedary camels from markets and slaughterhouses. GIT helminth infections such as haemonchosis, onchocerciasis, dipetalonemiasis, fasciolosis and hydatidosis have also been commonly reported (Toaleb *et al,* 2025). Parasitic helminths are responsible for various conditions in camels such as weight loss, poor body condition, poor growth, diarrhoea, low productivity, reduced immunity level and higher exposure to other infections. Different

SEND REPRINT REQUEST TO BARBARA PADALINO email: barbara.padalino@unibo.it, barbara.padalino@scu.edu.au

studies reported gastrointestinal parasites. For instance, in Algeria, 17% and 23.7% protozoan and helminth infections were reported, respectively, with Eimeria spp. reported as the most predominant protozoan species (Bouragba *et al,* 2020). In Iran, Radfar *et al* (2013) reported a high prevalence of GIT parasites in free range manged dromedary camels, in particular the authors quantify the incidence of *Nematodirus* spp. (52%), *Trichostrongyle* type eggs (49%), *Haemonchus* spp. (38 %), *Trichuris* spp. (14%) *Marshallagia* spp. (10%) and *Eimeria cameli* (24%).

In contrast, despite a national herd exceeding 116,000 head in Qatar in 2021 (Sanaullah, 2022) and a country with an extremely lofty proportion of camel livestock kept in several markets around the country (Faye, 2020), we found no published epidemiological studies conducted in this country (El-Alfy *et al,* 2024). To generate initial, practice-oriented data on disease patterns in Qatar, we performed a cross-sectional assessment of common cutaneous diseases and gastrointestinal (GI) parasitism among dromedary camels kept at a livestock market in Doha.

## Materials and Methods

### *Study area and animals*

This market-based survey was conducted over one day at a camel market in Doha, Qatar, in September 2019. Sampling was performed in the morning, from 8.00 to 11.00 am, with an average temperature of 42.3°C and 32.2% humidity, respectively. The camels were kept in different-sized pens in the market for different purposes, namely for meat, milk, breeding, racing; they were kept there permanently or temporarily until they were sold for slaughter or traded live. The camels originated from different countries (i.e., Qatar, Sudan, Oman, Saudi Arabia, United Arab Emirates, Kuwait, Pakistan and Somalia). A convenience sample of 15 dromedary camels with visible skin lesions was subjected to dermatologic examination (Table 1). Fresh, spontaneously voided faecal samples were obtained from nine animals for GI parasite testing (Table 1).

### *Data collection and analysis*

Each pen was visited in the market and then several pictures of the skin disorders were taken for their macroscopic description. Most of the animals kept at the market were non-handled, so it was not easy to approach and restrain them without causing evident distress, fear and pain. Consequently, to comply with ethical procedures in animal research, only non-invasive sampling methods were performed on the camels, which were coping well with the procedures. The animals were approached calmly and gently to take a non-invasive skin sample. If the animal defecated, a fresh faecal sample was also collected, as rectal sampling was not approved.

### *Macroscopic observation*

Lesions were recorded based on anatomic distribution, primary and secondary morphology (e.g., alopecia, nodules, macules, crusts and hyperpigmentation) and extent. The underlying cause of the presence of lesions could not be determined solely from external inspection.

### *Microscopic examinations*

Two non-invasive cytologic techniques were used:

Adhesive tape impression cytology (ATIC): The adhesive surface of transparent tape was pressed repeatedly onto skin lesions. Tapes were stained with Diff-Quik and applied sticky-side down to a glass slide for light microscopy examination.

Superficial skin scraping cytology (SSSC): Superficial keratin, hairs and crusts from the lesion were collected using a sharp curette or blunt scalpel blade. Smears were prepared on glass slides, stained with periodic acid–Schiff and examined microscopically for keratin changes, fungal spores (arthroconidia) and yeast-like organisms.

Organism identification was limited to morphology on superficial preparations. Fungal culture and molecular assays were not performed. Accordingly, organisms could not be assigned to genus or species and findings are reported as patterns compatible with superficial dermatophytosis and Ixodidae infestation rather than species-level diagnoses.

All microscopic pictures were taken using an ocular (an eyepiece), using Carl Zeiss AX190 digital microscope with camera system (Carl Zeiss, Jena, Germany).

### *Faecal examination for GI parasites*

Fresh faeces from nine camels were refrigerated at 4°C and analysed using the Mini-FLOTAC flotation method (KRUUSE Faecal Ova 3 Step, Cat. No. 291011, Langeskov, Denmark) with saturated magnesium sulfate solution, specific gravity 1.20 and pH 5.5 (KRUUSE Fasol, 1 L, Car. No. 291015, Langeskov, Denmark), following the manufacturer's instructions. The protocol was chosen for its

**Table 1.** Cases examined in the present study.

| Camel ID | Age | Sex | Skin colour | Body condition score (BCS) | Faecal sample |
|---|---|---|---|---|---|
| 1 | Adult | Female | Beige | 2 | Not collected |
| 2 | Adult | Female | White | 5 | Collected |
| 3 | Adult | Female | White | 3 | Not collected |
| 4 | Yearling | Male | Black | 2 | collected |
| 5 | Yearling | Male | Beige | 2 | Not collected |
| 6 | Yearling | Male | White | 2 | collected |
| 7 | Calf | Female | White | 1 | Not collected |
| 8 | Adult | Female | Beige | 2 | collected |
| 9 | Calf | Male | Beige | 1 | collected |
| 10 | Adult | Female | Beige | 2 | Not collected |
| 11 | Yearling | Male | Beige | 2 | collected |
| 12 | Yearling | Male | White | 1 | collected |
| 13 | Adult | Female | Beige | 2 | Not collected |
| 14 | Old Age | Female | White | 1 | collected |
| 15 | Yearling | Male | Beige | 2 | collected |

reported analytical sensitivity in detecting protozoal oocysts and helminth eggs (Mohammedsalih *et al,* 2025). Outcomes were recorded quantitatively as quantitative counts of oocysts or helminth eggs. Eimeria species were identified according to their morphological features (Al-Shaebi *et al,* 2024; Metwally *et al,* 2020).

## Results

### *Skin lesions*

### *Macroscopic findings*

Lesions varied in size and shape and were broadly classified as alopecia or nodular/macular lesions. Among 15 animals, alopecia was present in 13 (Camel ID: 1-6, 8-10, 12-15); nodules/macules in one (Camel ID: 7); and mixed lesions in one (Camel ID: 11) (Table 2, Fig 1-4). Hyperpigmentation or crusting is frequently accompanied by alopecia (Fig 1, 3). Lesions were unevenly distributed, primarily affecting the neck, shoulders, abdomen and hump (Fig 1-4).

### *Microscopic findings*

ATIC: Larval (seed) ticks were found in two animals (Camel ID: 9, 11), with morphology characterised by 3 pairs of legs, lack of a scutum and smaller than adult hard ticks (family Ixodidae) (Table 2, Fig 5). Hyperkeratosis, characterised by numerous anuclear keratinocytes and keratin debris, was observed in eight animals (Camel ID: 3-6, 8-10, 12) (Fig 6); exudative dermatitis with inflammatory cell infiltration in three (Camel ID: 2, 11, 13). No cytologic abnormalities were observed in four animals (Camel ID: 1, 7, 14 and 15). Among hyperkeratotic cases, severity was graded as mild in one case (Camel ID: 10) and moderate in seven cases (Camel ID: 3-6, 8, 9, 12) (Table 2).

**Table 2.** Macro- and microscopic findings of skin lesions.

| Camel ID | Macroscopy | | ATIC | | | SSSC | | |
|---|---|---|---|---|---|---|---|---|
| | | LT | HK | ED | DP | Tick | SK and ED | Yeast |
| 1 | AL | N | N | N | N | N | Mild | N |
| 2 | AL | N | N | + | + | N | Moderate | N |
| 3 | AL | N | + | N | N | N | Moderate | N |
| 4 | AL | N | + | N | N | N | Moderate | N |
| 5 | AL | N | N | N | N | N | Moderate | + |
| 6 | AL | N | + | N | + | N | Moderate | N |
| 7 | A, NM | N | N | N | N | N | Moderate | + |
| 8 | AL | N | + | N | + | N | Mild | N |
| 9 | AL | + | + | N | + | + | Moderate | N |
| 10 | AL | N | + | N | N | N | Moderate | + |
| 11 | AL, NM | + | N | + | + | + | Moderate | N |
| 12 | AL | N | + | N | N | N | Moderate | N |
| 13 | AL | N | N | + | N | N | Moderate | N |
| 14 | AL | N | N | N | N | N | Moderate | + |
| 15 | AL | N | N | N | N | N | Mild | N |

**Remarks** LT: Larval tick, AL: Alopecia, NM: nodular or macular lesions, N: not found, HK: hyperkeratosis, ED: exudative dermatitis, DP: dermatophytosis, SK&ED: seborrhoeic keratosis and exudative dermatitis, Yeast: Yeast-like bodies, +: found.

SSSC: Hair shaft arthroconidia consistent with dermatophytosis were identified in five animals (Camel ID: 2, 6, 8, 9, 11) (Table 2). Round spores were present both within the hair shaft (endothrix) (Fig 7, 8) and on the hair surface (ectothrix) (Fig 9, 10). Spores occurred singly or in short chains and were sometimes embedded within keratin. The fungal species of dermatophytes could not be determined by their microscopic morphology. Spore-positive hairs showed localised shaft thickening with cuticular lifting, partial or complete cuticle loss, shaft fractures with split ends (trichoptilosis) and altered melanin granules (Fig 8-10). Spores were confined to hair shafts, with no root/follicular involvement, consistent

with superficial dermatophytosis. Yeast-like, light pink-to-red spherical bodies were observed in four animals (Camel ID: 5, 7, 10, 14) (Fig 11). Hyphae or pseudohyphae were not observed in spore- or yeast-positive cases.

Across all cases, exfoliated keratinocytes and keratin debris (scales) and scab material (coagulated exudate mixed with sebaceous debris) adhered to hairs or were present in the background. Overall, cytologic changes were interpreted as seborrhoeic keratosis and exudative dermatitis. Four cases were classified as mild (Camel ID: 1, 6, 8, 15) and 11 were classified as severe (Camel ID: 2-5, 7, 9-14). No inflammatory cell infiltration was detected on SSSC.

### *Faecal examination*

Two species of Eimeria (*Eimeria dromedarii* and *Eimeria cameli*) were observed in 3/9 faecal samples (Camel ID: 4, 9 and 15). No nematode or cestode eggs were observed (Table 3).

**Table 3.** Results of faecal egg counts from the nine dromedary camels.

| Camel ID | Faecal egg counts |
|---|---|
| 2 | No helminthic eggs detected |
| 4 | 550 oocysts per gram (OpG) *Eimeria cameli* |
| 6 | No helminthic eggs detected |
| 8 | No helminthic eggs detected |
| 9 | 300 oocysts per gram (OpG) *Eimeria cameli* |
| 11 | No helminthic eggs detected |
| 12 | No helminthic eggs detected |
| 14 | No helminthic eggs detected |
| 15 | 250 oocysts per gram (OpG) *Eimeria dromedarii* |

## Discussion

This market-based survey documented heterogeneous cutaneous lesions and GI protozoal parasitism among dromedary camels in Doha, Qatar. While wide range of skin lesions were reported in literatures such as alopecia, macules, papules, nodules, plaques, masses, vesicles, pustules, scales, crusts (Abdel-Saeed, 2020; Ngeiywa, 1992; Osman, 2014), our investigation identified lesions of varying size and shape that were mainly classified as alopecia or nodular/macular lesions.

Hyperpigmentation or crusting was frequently accompanied by alopecia. Lesions were unevenly distributed, primarily affecting the neck, shoulders, abdomen and hump. This lesion pattern could be suggestive of mixed infections. Similar non-pruritic, dry, crusted alopecic lesions have been reported in dromedaries with dermatophytosis in Saudi Arabia (Almuzaini *et al,* 2016). In our study, most alopecic lesions showed cytological features of seborrhoeic or exudative dermatitis, while some were consistent with dermatomycosis and hair shaft fragility. Accumulation of sebaceous debris and crusts may have created a favourable environment for fungal or yeast proliferation, potentially worsening dermatitis and alopecia (Miller *et al,* 2012; Rodrigues Hoffmann *et al,* 2023). Yeast-like elements reminiscent of Malassezia were occasionally observed; given that Malassezia can be part of normal skin microbiota in many mammals, their clinical significance requires cautious interpretation in the absence of culture or molecular analyses (Miller *et al,* 2012; Rodrigues Hoffmann *et al,* 2023). In a mixed infection of dermatomycosis and mange, Al-Salihi *et al* (2013) described dermatitis characterised by acanthosis, parakeratosis, hyperkeratosis, crust formation, sebaceous gland hyperplasia, granulomatous hidradenitis and infiltration of eosinophils, lymphocytes, macrophages and neutrophils. The authors also revealed numerous fungal arthrospores and hyphae using histological sections stained with periodic acid-Schiff (PAS) and Gomori's Methenamine silver (GMS). Although our investigation did not detect hyphae or immune cell infiltration, similar skin lesions were observed in the examined samples.

In this prelimary investigation, even though different macroscopic skin lesions, which may be suggestive of mixed infection was observed, we had only identified the larval stage of ticks. This could be due to the sampling and diagnostic methods limitations we had in the investigation. Seed ticks morphologically consistent with the family Ixodidae were found on two camels, in line with the literature (Mathison and Pritt, 2014). Even if ticks can be identified only using morphology, future studies should include deeper investigation of ticks and screening for tick-borne pathogens (TBPs) similar to a recent study (Getange *et al,* 2021). Regional surveys indicate that Hyalomma is the predominant tick genus infesting dromedary camels across East and North Africa, including Kenya, Ethiopia, Algeria and Somalia (Hamza *et al,* 2019; Khelifi-Ouchene *et al,* 2020; Getange *et al,* 2021; Desta, 2025). A study in the United Arab Emirates (UAE), discovered *Hyalomma dromedarii* as the predominant tick species (Camp *et al,* 2020). Collectively, these findings suggest that the infestations observed in our study may represent more than simple bite-related dermatitis and justify the need for a larger study including

**Fig 1.** Alopecia on the chest and shoulders and the skin was dark (hyperpigmentation) (Camel ID: 5).

**Fig 2.** Numerous alopecic lesions, with crusty skin all over the body (Camel ID: 9).

**Fig 3.** Numerous small, round alopecic lesions on the neck, which appear dark (Camel ID: 8).

**Fig 4.** Nodular/macular lesions on the abdominal and respiratory regions.


**Fig 5.** Larval (seed) tick (Camel ID: 9). under microscope 10 x objective lens.

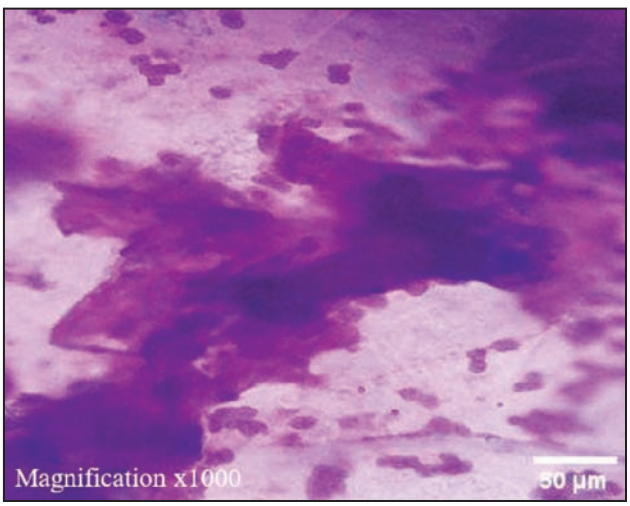



**Fig 6.** Yeasts and large numbers of the scales and scabs in the background under 100 x objective lens. Magnification= x 1000. (Camel ID: 10).

blood testing for TBPs due to potential animal health, zoonotic and public health risks, as previously done in other countries (El-Alfy *et al,* 2024). Mange is a most prevalent and debilitating cutaneous disease caused by mites (e.g., Sarcoptes, Demodex) in dromedary camels (Gharban, 2024). Although mange was not detected in all examined animals, negative superficial skin scrapings do not rule out infestation, as follicular mites reside deep within pilosebaceous units and require deep scrapings until capillary bleeding for detection (Miller *et al,* 2012). However, as this is an invasive procedure not permitted for our research purpose, this may remain

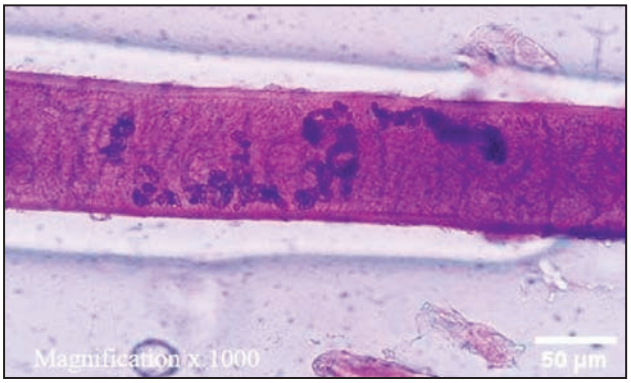



**Fig 7.** Endothrix in the core area of the hair shaft under the microscope with a 100 x objective lens. Magnification=x 1000 (Camel ID: 6).

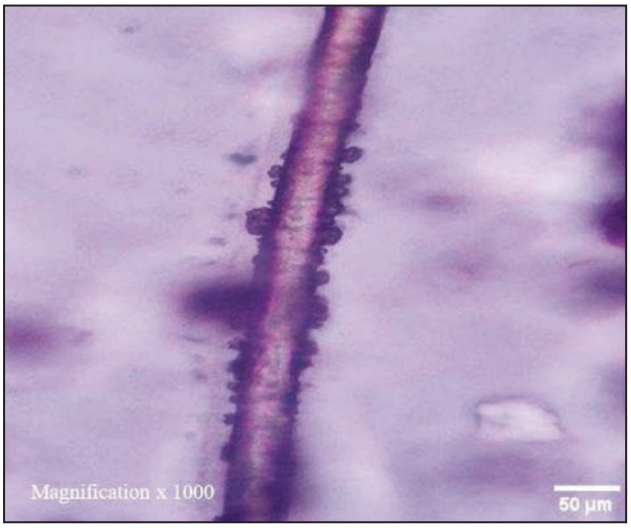



**Fig 9.** Ectothrix in the cuticle surface under a microscope with a 100x objective lens. Magnification= x 1000. (Camel ID: 9).

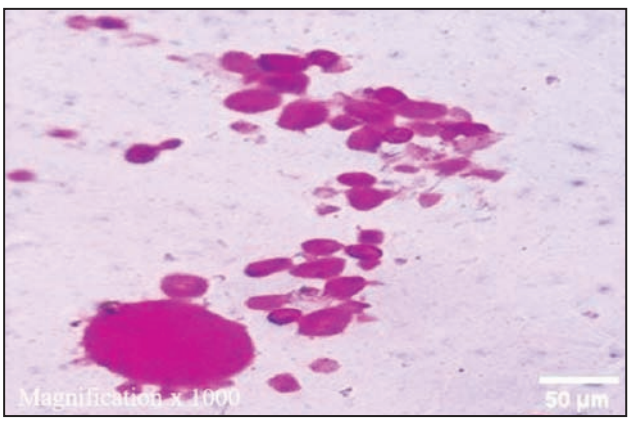



**Fig 11.** Many yeasts in the background under a microscope with a 100x objective lens. Magnification= x 1000. (Camel ID: 7).

a diagnostic tool advised under veterinary practice. Mange adversely affects camel welfare by causing pruritus, distress, reduced feed intake, weight loss, immune compromise and increased susceptibility to

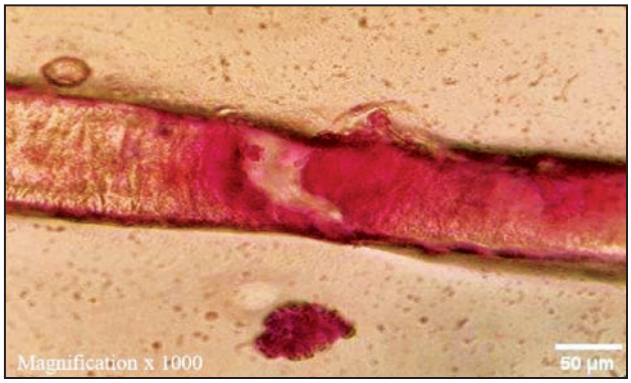



**Fig 8.** Fungal spore (endothrix) infection, frequent hair damage. Broken hair shaft at the site of endothrix under the microscope with a 100x objective lens. Magnification=x 1000. (Camel ID: 6).

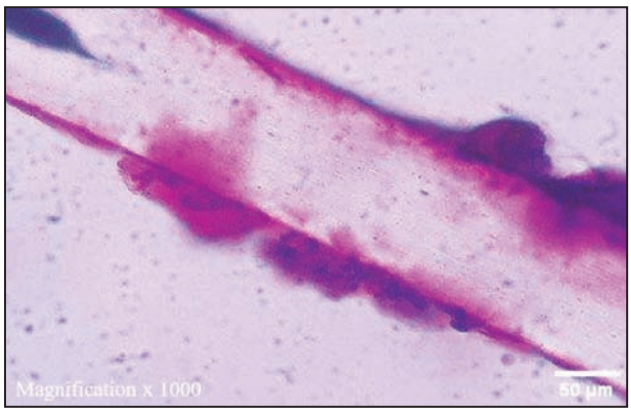



**Fig 10.** Fungal spore (ectothrix) infection with marked hair damage (loss of melanin granules) under a microscope with a 100x objective lens. Magnification= x 1000. (Camel ID: 2).

infections and is characterised clinically by alopecia, erythema, crusting and a rough coat (Chalchisa and Bersissa, 2023). Therefore, regular veterinary monitoring is recommended at markets as thorough diagnosis, timely treatment and effective prevention are essential to improve the health and welfare of dromedary camels.

Oocysts of *Eimeria cameli* and *dromedarii* were present in one-third of the tested faecal samples; no helminth eggs were detected. These results align with reports demonstrating the presence of protozoal enteroparasites being predominant in dromedary camels. For example, in Southern Algeria, using similar flotation methods, *Eimeria* spp. and *Balantidium* spp. were detected commonly and with only few helminths reported (Bouasla *et al,* 2023). Similarly, in Iran (Radfar and Aminzadeh Gowhari, 2013) and Egypt (El-Khabaz *et al,* 2019), *Eimeria* spp. was also identified as a common gastrointestinal parasite in camels Overall, the literature suggests that protozoal infections, particularly *Eimeria*

spp., are more prevalent than helminth infections in dromedary camels, highlighting the need for appropriate treatment and preventive measures (Metwally *et al,* 2020). Eimeria infects intestinal mucosal epithelium and can impair digestion (Mohammed, 2023), future studies should therefore link oocyst counts to species identification, clinical signs and body condition scores to clarify clinical significance.

This preliminary survey highlights the occurrence of skin diseases and protozoal infestations in market-kept camels. Parasitic infections adversely affect camel welfare by causing pain, weight loss, immune compromise and increased susceptibility to secondary infections (Toaleb *et al,* 2025). Although deworming is commonly practised by camel handlers, it is often done without veterinary prescription, which may promote inappropriate drug use and parasite resistance (Padalino *et al,* 2021; Padalino *et al,* 2024). Therefore, targeted control strategies, including veterinary-guided treatment and routine faecal egg counts rather than indiscriminate deworming, should be implemented to improve camel health and welfare (Nielsen, 2012).

Our data need to be interpreted with caution, as this preliminary study has its own limitations. Firstly, the sample size was very limited and the sampling was conducted in a single market, so our preliminary findings cannot be generalised to all markets. Secondly, only a superficial skin scraping sample was collected and consequently, the presence of the deep borrowing mites could have been underestimated. In addition, fungal hyphae or pseudohyphae were not detected in our sample and further mycological tests should have been performed to confirm the diagnosis. Finally, as we did not use any invasive collection methods, we collected faecal samples only from 9/15 camels, reducing even further our sample size and the possibility to identify helminth eggs. Notwithstanding those limitations, our study has increased our knowledge of skin disorders and parasite infections of dromedaries kept in a market in Qatar, providing some useful suggestions, such as increasing veterinary monitoring to better protect the welfare of dromedary camels kept at markets

## Conclusions

Despite the limitations of this preliminary investigation, the findings highlight heterogeneous but predominantly superficial dermatologic processes and protozoal GI parasitism in market camels. These conditions likely reflect suboptimal husbandry practices common in animal markets, including high stocking density, poor hygiene, mixing and regrouping of animals. Given the potential risk of tick-borne pathogens, further studies incorporating morphological tick species identification and pathogen screening are warranted, along with routine monitoring by official veterinarians. Overall, these preliminary data support the need for improved management practices to enhance the welfare of dromedary camels at markets.

## Acknowledgements

We thank Dr. Wasiq Mehmood and Ms. Janinne C. Manuel of the Veterinary Diagnostic Laboratory belonging to Equine Veterinary Medical Centre (Doha, Qatar) for their assistance.

## Funding

This research was funded by Animals' Angels.

## Disclosure

The authors declare no conflict of interest in relation to the research, authorship or publication of this article.

## Ethical Statement

The study was conducted according to the guidelines of the Declaration of Helsinki. The research project was run with the permission of the Department for Agriculture Affairs and Fisheries of the Ministry of Municipality and Environment of the State of Qatar (Approval code 2404/2020). The study involved no invasive sampling methods and all data collection was performed without disturbing the animals. Oral owners' consents were received before the assessment.

## Author contributions

Conceptualisation of the study was done by Masa-aki Oikawa, Barbara Padalino. Data collection was done by Masa-aki Oikawa, Barbara Padalino, Jessica P. Johnson and Midori G. Asakawa. Laboratory investigation was done by Masa-aki Oikawa, Jessica P. Johnson and Midori G. Asakawa. Data analysis and drafting of the manuscript were done by Naod Thomas Masebo, Masa-aki Oikawa and Barbara Padalino. Reviewing, writing and proofreading were done by Naod Thomas Masebo, Barbara Padalino, Jessica P. Johnson and Midori G. Asakawa. Masa-aki Oikawa and Barbara Padalino supervised the entire research work.

## Data availability

The data generated during the study can be requested from the corresponding author.

## References


Abbas B and Omer O. Review of infectious diseases of the camel. Veterinary Bulletin. 2005; 75(8):1-16

Abdel-Saeed H. Clinical, haematobiochemical and trace-elements alterations in camels with Sarcoptic mange (*Sarcoptes Scabiei var Cameli*) accompanied by secondary pyoderma. Journal of Applied Veterinary Sciences. 2020; 5(3):1-5.

Ahmed MA, Elmahallawy EK, Gareh A, Abdelbaset AE, El-Gohary FA, Elhawary NM, Dyab AK, Elbaz E and Abushahba MF. Epidemiological and histopathological investigation of sarcoptic mange in camels in Egypt. Animals. 2020;10(9):1485.

Alanazi AD, Nguyen VL, Alyousif MS, Manoj RR, Alouffi AS, Donato R, Sazmand A, Mendoza-Roldan JA, Dantas-Torres F and Otranto D. Ticks and associated pathogens in camels (*Camelus dromedarius*) from Riyadh Province, Saudi Arabia. Parasites & Vectors. 2020; 13(1):110.

Almuzaini AM, Osman SA and Saeed EM. An outbreak of dermatophytosis in camels (*Camelus dromedarius*) at Qassim Region, Central of Saudi Arabia. Journal of Applied Animal Research. 2016; 44(1):126-129.

Al-Salihi K, AbdHatem A and Ekman E. Pathological studies on mixed dermatomycosis and mange infection in camels accompanied with chronic granulomatous hidradenitis. Journal of Camel Practice and Research. 2013; 20(2):309-315.

Al-Shaebi EM, Al Quraishy S, Omer SA, Abdel-Gaber R and Mohammed OB. Morphological and molecular identification of Eimeria rajasthani (coccidia: Eimeriidae) in the dromedary camel (*Camelus dromedarius*) in Riyadh, Saudi Arabia. Frontiers in Veterinary Science. 2024; 11:1464138.

Bouasla I, Mekroud M, Khelifi Touhami NA, Dib M, Bouhabila H, Daif S, Ouchene N, Titi A and Benakhla A. Gastrointestinal parasite infestation of the dromedary camel (*Camelus dromedarius*) in southern Algeria. Biology and Life Sciences Forum. MDPI; 2023:19.

Bouragba M, Laatamna A, Cheddad F, Baroudi D, Houali K and Hakem A. Gastro-intestinal Parasites of Dromedary Camel (*Camelus dromedarius*) in Algeria. Veterinary World. 2020; 13(8):1635-1640.

Camp JV, Kannan DO, Osman BM, Shah MS, Howarth B, Khafaga T, Weidinger P, Karuvantevida N, Kolodziejek J, Mazrooei H and Wolf N. Crimean-Congo haemorrhagic fever virus endemicity in United Arab Emirates, 2019. Emerging Infectious Diseases. 2020; 26(5):1019.

Chalchisa A and Bersissa E. Ectoparasites and their effect on camels (*Camelus dromedarius*) in Ethiopia. Journal of Veterinary Research Advances. 2023 ;5(1):55-69.

Desta A Hadush. Ectoparasites of Camels (*Camelus dromedarius*) in Afar Pastoral Areas of Ethiopia. Veterinary Medicine International. 2025; DOI: 10.1155/vmi/5550074.

El-Alfy E-S, Abbas I, Saleh S, Elseadawy R, Fereig RM, Rizk MA and Xuan, X. Tick-borne pathogens in camels: a systematic review and meta-analysis of the prevalence in dromedaries. Ticks and Tick-borne Diseases. 2024; 15(1):102268.

El-Khabaz KA, Abdel-Hakeem SS and Arfa, MI. Protozoan and helminthes parasites endorsed by imported camels (*Camel dromedarius*) to Egypt. Journal of Parasitic Diseases. 2019; 43(4):607-615

Faye B. How many large camelids in the world? A synthetic analysis of the world camel demographic changes. Pastoralism. 2020; 10(1):25.

Getange D, Bargul JL, Kanduma E, Collins M, Bodha B, Denge D, Chiuya T, Githaka N, Younan M and Fèvre EM. Ticks and tick-borne pathogens associated with dromedary camels (*Camelus dromedarius*) in northern Kenya. Microorganisms. 2021; 9(7):1414.

Gharban HA. Article Review: Skin Diseases in Dromedary Camels. Journal La Lifesci. 2024; 5(3):206-217.

Hamza H, Guled S and Abdirabbi S. Prevalence of tick infestation in dromedary camels (*Camelus dromedarius*) brought for slaughter in Mandeeq Abattoir, Hargeisa Somalia. World journal of pharmacy and pharmaceutical sciences. 2019; 39(1):452.

Jain GK, Singh A, Tanwer J, Marwaha S and Chahar A. Epidemiological studies on sarcoptic mange in camels (*Camelus dromedarius*) in Bikaner district (West Rajasthan). Journal of Parasitic Diseases. 2005; 29(1):67-70.

Kamili A, Faye B, Bengoumi M and Tligui NS. Invited review: Camel skin diseases survey in Morocco. Journal of Camelid Science. 2019; 12:1-16

Khelifi-Ouchene NA, Ouchene N, Dahmani A, Kaaboub EA, Ouchetati I and Haif A. Investigation of internal and external parasites of the camels (*Camelus dromedarius*) in Algeria. Annals of Parasitology. 2020; 66(3):331-337.

Kinne J and Wernery U. Experimental mange infection in camels (*Camelus dromedarius*). Journal of Camel Practice and Research. 2003; 10(1):1-8.

Mathison BA and Pritt BS. Laboratory identification of arthropod ectoparasites. Clinical Microbiology Reviews. 2014; 27(1):48-67.

Menchetti L, Zappaterra M, Nanni Costa L 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(2):494.

Metwally DM, Al-Otaibi TT, Albasyouni SA, El-Khadragy MF and Alajmi RA. Prevalence of eimeriosis in the one-humped camels (*Camelus dromedarius*) from Riyadh and Al-Qassim, Saudi Arabia. PeerJ. 2020; 8:e10347.

Miller WH, Griffin CE and Campbell KL. Muller and Kirk's small animal dermatology. Elsevier Health Sciences. 2012; pp 198-256

Mohammed RS. Histopathological Studies of *Eimeria cameli* in the intestine of infected onehumped camel (*Camelus dromedarius*). Alexandria Journal of Veterinary Sciences. 2023; 78(1):94-100

Mohammedsalih KM, Hassan SA, Juma F-R, Saeed, SI, Bashar A, von Samson-Himmelstjerna G and Krücken J. Comparative assessment of Mini-FLOTAC, McMaster and semi-quantitative flotation for helminth egg examination in camel faeces. Parasites and Vectors. 2025; 18(1):5.

Ngeiywa J. Clinical and pathological investigations on camel skin diseases in some camel rich districts of Northern Kenya. Unpunished Master's Thesis (MSc). University of Nairobi, Nairobi Kenya. 1992.

Nielsen MK. Sustainable equine parasite control: perspectives and research needs. Veterinary Parasitology. 2012; 185(1):32-44.

Osman SA. Camel dermatophilosis: Clinical signs and treatment outcomes. Journal of Camel Practice and Research. 2014; 21(2):199-204.

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.

Padalino B and Menchetti L. The first protocol for assessing welfare of camels. Frontiers in Veterinary Science. 2021; 7:631876.

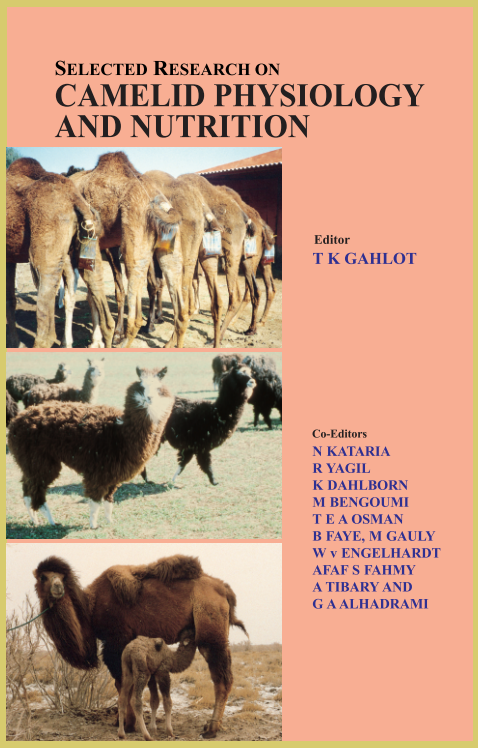
Padalino B, Thomas MN, Benedetti B, Abdelali Z and Menchetti L. Knowledge and perception of animal welfare at the camel market in Egypt. Journal of Camelid Science. 2024; 18:13-36.

Radfar MH and Aminzadeh Gowhari M. Common gastrointestinal parasites of indigenous camels (*Camelus dromedarius*) with traditional husbandry management (free-ranging system) in central deserts of Iran. Journal of Parasitic Diseases. 2013; 37(2):225-230.

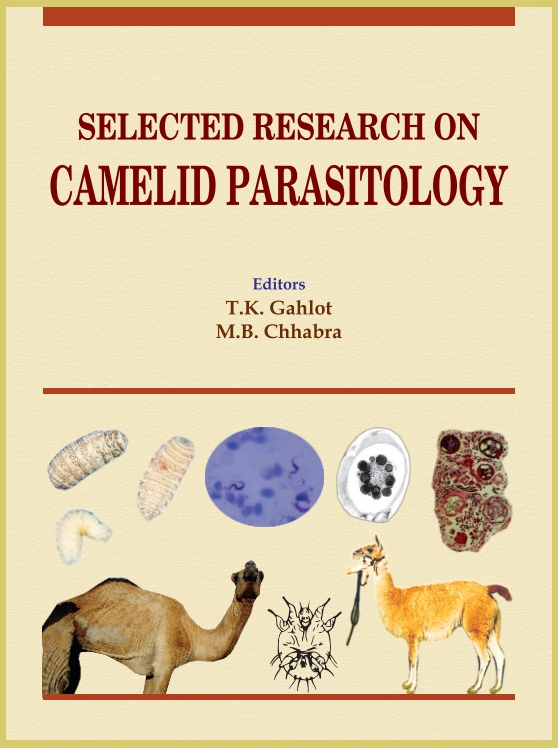
Rodrigues Hoffmann A, Ramos MG, Walker RT and Stranahan LW. Hyphae, pseudohyphae, yeasts, spherules, spores and more: A review on the morphology and pathology of fungal and oomycete infections in the skin of domestic animals. Veterinary Pathology. 2023; 60(6):812-828.

Sanaullah Ataullah. Livestock sector sees robust growth. The Peninsula, Published: March 07. 2022.

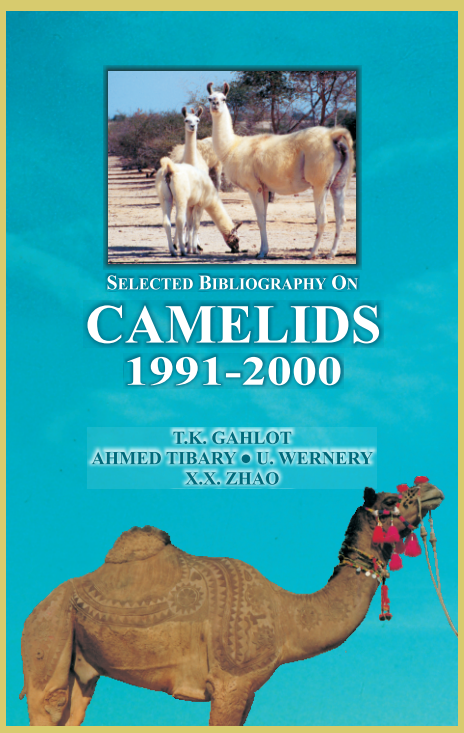
Toaleb NI, Shaapan RM, Abu El Ezz NM and Abbas WT. Parasitic Helminths and Arthropods Infections in Camel: Diagnosis and Control. Proceedings of the National Academy of Sciences, India Section B: Biological Sciences. 2025; 95(2):267-275.



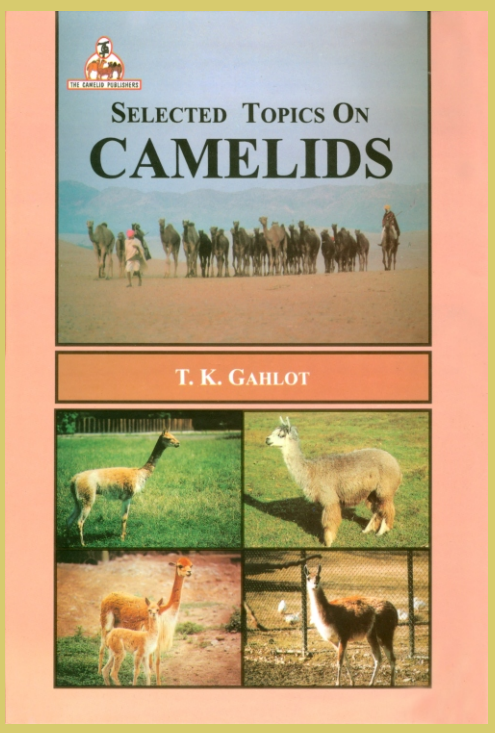

INR 1950
US$ 180




INR 3000
US$ 200




INR 950
US$ 80




INR 1950
US$ 180

Order on tkcamelvet@yahoo.com
Website www.camelsandcamelids.com

DOI : 10.5958/2277-8934.2026.00007.9 Vol 33 No 1, p 51-58

# DESCRIPTIVE TYPOLOGY OF CAMEL MILK QUALITY IN TOUGGOURT, SOUTHERN ALGERIA

**Linda Maya Mansour[1], Férial Aziza Benyahia[2] and Ouarda Aissaoui Zitoun[3]**

[1]Laboratory for the Improvement and Development of Plant and Animal Production, Ferhat Abbas University, Sétif, Algeria
[2] Agro-Food Engineering Laboratory (GENIAAL) INATAA-UFMC1, [3]Laboratory of Nutrition and Food Transformation (LNTA), National Institute of Food, Nutrition and Agri-Food Technologies (INATAA), Mentouri Brothers University, Constantine, Algeria

## ABSTRACT

The objective of this work is to identify the diversity of camel milk quality in the arid region of Touggourt, and to classify the milk samples according to physicochemical parameters in order to have a real and correct vision of the quality of the milk produced in this region. A total of seventy-five samples of mixed milk were taken from various communes in Touggourt for physico-chemical analysis, including the following parameters: pH, lactose content, protein content, mineral content and fat content. The results of the analyses were processed to produce a typology close to the reality of the quality of camel milk produced in the study area. Milk quality parameters are highly variable but generally considered acceptable. The results show that the pH of Touggourt camel milk is equal to 6.62±0.57. It is close to that found in Saudi Arabia and Tunisia. At the same time, the collected milk has an overall acceptable composition of basic nutrients (protein, fat and lactose). The fat content is equal to 34.76±5.85. Camel milk also contains a protein level equal to 33.21±2.54 and 47.28±3.94 for lactose. It contains 3.17±0.95 of minerals. The typology of the analysed camel samples revealed 04 classes of milk. The main sources of variation were the fat and mineral content.

**Key words:** Algeria, camel milk, descriptive analysis, diversity, physico-chemical composition, Saharan regions

The emergence of awareness of the benefits of camel milk in Algeria is recent, hence the enthusiasm to promote this breeding. Indeed, in recent years, camel breeding has begun to develop and even move towards intensification, particularly for the production and marketing of milk (Bedda *et al,* 2019).

In terms of scientific research, camel milk has attracted increasing interest in recent years on various aspects such as production, nutritional composition, functional properties and optimisation of coagulation parameters (Bouras *et al,* 2022, AL Hadj and Al Kanhal, 2010). The study of the quality parameters of this milk across the different producing regions of Algeria is lacking. The objective in present study was therefore aimed to assess the quality of the milk produced in one of the camel milk producing areas, the Touggourt region in southern Algeria.

## Materials and Methods

The physicochemical characteristics of camel milk from the Touggourt region and its production conditions was studied.

### *Survey*

The survey was conducted among 25 breeders in the Touggourt region (Algeria) using an individual questionnaire. The choice of the study region was based on the existence of a relatively large camel population, accessibility to the region in all seasons, security concerns, and the availability of breeders willing to collaborate with our study

The Touggourt region is a group of oases located in the south-east of Algeria, 160 km north-east of Ouargla, 225 km south of Biskra and approximately 600 km south-east of Algiers (Map 1). The sampling was carried out on the basis of information collected at the level of the Directorates of Agricultural Services (administrative unit) of the Daïra (Table 1).

Each breeder's camel milk was subjected to a physicochemical analysis during the spring season with 3 samples per breeder. Milk samples were taken from small herds at the farm to determine the quality of the milk immediately after the morning milking.

### *Camel milk sampling*

These milk samples came from herds of healthy Sahraoui camels. The animals ranged in age from 7 to 22 years. Lactation ranks ranged from 2 to 6. A total of 75 samples were analysed for 9 variables, representing 675 data points.

SEND REPRINT REQUEST TO LINDA MAYA MANSOUR email: mlyndamaya@yahoo.fr / mansourlm@univ-setif.dz

### *Physico-chemical analysis of milk*

pH was measured using a pH meter (LinoLab pH 720). Dry matter, fat content, ash, total solids (T.S), solids non-fat (S.N.F), lactose and protein in milk samples were measured using a Lactoscan previously calibrated (Lactostar, Funke Gerber 3510).

### *Statistic analysis*

Milk quality characteristics were first described using descriptive statistics. Then, a one-way ANOVA was used to analyse the impact of breeding practices on the physicochemical composition of camel milk. A principal component analysis (ACP) followed by an ascending hierarchical classification was then carried out to establish a typology of the samples according to five quality variables (lactose, proteins, freezing point, minerals, fat). The analysis was carried out using SPSS version 23 software.

## Results and Discussion

### *Overall physico-chemical quality of camel milk (Table 2)*

The pH is the first parameter that informs us about the freshness of the milk and plays an important role in determining its quality (El Hosseny *et al*, 2018). The pH of the milk samples analysed was between 5.09 and 7.09 with an overall average of 6.62±0.57 which agrees with the values given by the FAO (1982) for camel milk, i.e. 6.5 - 6.7 (FAO, 1982) and the value given for the same Sahrawi breed by Bouras *et al* (2022) i.e. a pH of 6.56±0.34.

Variations in the pH of camel milk can be explained by various environmental and physiological factors, including geographical location, climate, diet, water availability, breed, stage of lactation and age of the animal (Gorban and Izzeldin, 1997; Al-Haj and Al-Kanhal, 2010). The pH is therefore an essential indicator of milk quality and health status, particularly for the detection of mastitis (Sharma, 2006).

The naturally lower pH of camel milk compared to cow's milk is partly due to its high vitamin C content (Saley, 1993). The slight variation in pH during the first 24 hours of storage can be explained by the strong buffering capacity of camel milk, as reported by Farah and Ruegg (1989), Ramet (1994) and Abu-Tarboush (1996), confirming its short-term stability (Kaskous, 2019). On the other hand, prolonged storage leads to gradual acidification due to the fermentation of lactose into lactic acid, resulting in pH values below 5, in agreement with Sodini *et al* (2002) and Fguiri *et al* (2017).

The pH values recorded in this study are also within the range of values reported by many authors who have worked on camel milk in the Ouargla region of Algeria (Siboukeur, 2008; Mahboub, 2010). These values were also close to those reported by some authors in other regions as cited by Mehaia (1994) in Saudi Arabia (pH = 6.61±0.02), Kamoun (1995) in Tunisia (pH = 6.51±0.12) and Elhosseny *et al* (2018) in Egypt (6.61). Of the samples analysed, only 16% had a pH below 6 (between 5.09 and 5.59). On the other hand, the pH of camel milk depends on other factors, i.e. the nature of the fodder and the availability of water (Gorban and Izzeldin, 2001; Gorban and Izzeldin, 1997), the citrate and casein content and the health of the udder (Siboukeur, 2008).

The fat content of the milk analysed ranged from 24.2 to 46.9 g/l, with an overall average of 34.76g/l ±5.85. This average was in line with that found by Ellouze and Kamoun (1989); Gorban and Izzeldin (2001) (32 to 35 g/l) and was lower than that found by Kamal *et al* (2007) (37.8g/l), Sboui *et al* (2016) (37.5g/l) and also by Bouras *et al* (2022) (37.76±1.54 g/l). It lies between the extreme values recorded for the Somali breed and reported by Karue (1994) (56 g/l) and those recorded by Mehaia *et al* (1995) for the Wadah breed (24.6 g/l). In fact, Konuspayeva *et al* (2009) noted a wide variation in the fat content of camel milk throughout the world. The study by AL-Haj *et al* (2022), reports an overall average fat content of 3.47%. However, its physicochemical composition shows marked

**Table 1.** Distribution of breeders surveyed by municipality.

| The municipalities | Taibet | Touggourt | Tamacine | El mguarin | Total |
|---|---|---|---|---|---|
| Number of breeders surveyed | 11 | 6 | 4 | 4 | 25 |

**Table 2.** Average physicochemical characteristics of milk collected from the farms studied.

| | pH | MG | Lactose | Protéine | Minerals | Freezing point |
|---|---|---|---|---|---|---|
| Max | 7.09 | 46.9 | 58.8 | 39.9 | 4.9 | -0.43 |
| Mean ± Standard deviation | 6,62±0.57 | 34.76±5.85 | 47.28±3.94 | 33.20±2.54 | 3.17±0.95 | -0.55±0.03 |
| Min | 5.09 | 24.2 | 35.3 | 25.9 | 1 | -0.66 |

Max : maximum; Min :minimum


**Map 1.** Geographical location of the study area (Touggourt, Algeria). (https://d-maps.com/)

variability, attributable to various biological and environmental factors, including breed, season, geographical origin, diet and analytical methods, which explains the discrepancies observed between studies, particularly with regard to fat and lactose content.On the other hand, among the analysed milk samples, we found that only 20% of them have a fat content of less than 30 g/l. Abdalla *et al* (2015) explained that the low fat content of camel milk is a sign of poor nutrition in desert areas. Indeed, the composition of camel milk has been shown to vary widely in its constituents depending on physiological, genetic and environmental factors (Musaad *et al,* 2013).

In fact, morning milking gives milk that is relatively low in fat compared to evening milking (Kamoun,1994). This is due to the fact that the milk at the beginning of milking is a little wet and low in fat that has a more or less significant molecular weight, so it remains behind. This study is based on the analysis of mixed milk from morning milking. Previous studies indicate that the time of milking influences the composition of camel milk, with evening milking associated with higher levels of fat, acidity and certain minerals (Cl, P), while protein and lactose remain broadly stable. These results, in agreement with Nagy *et al* (2017) and Ayadi *et al* (2009), confirm that milk from morning milking is relatively lower in fat content.

The average total protein content of the analysed camel milk is equal to 33.20 g/l ± 2.54. This concentration is comparable to those mentioned by Siboukeur (2008) (35.68 ± 5.64 g/l) and by Kamoun (1994) (34.3 ± 4.4 g/l). However, it is higher than those reported by Mehaia *et al* (1995) which was 29.1 g/l and by Gnan *et al* in Libya (1994) (21.5 g/l) or Bouras *et al* (2022) in Algeria (28.6±0.4 g/l) and on the other hand it is lower than that recorded by Mohamed *et al* (1989) in Somalia (46 g/l). The nitrogenous substance in milk is found mainly in

**Table 3.** Results of the ANOVA analysis of one factor between and within milk classes.

| | | | | Sum of squares | ddl | Mean of squares | F | Signification |
|---|---|---|---|---|---|---|---|---|
| MG | Inter-group | (Combined) | | 2472,20 | 24 | 103,00 | 80,89 | ,00 |
| | | Linear term | Contrast | ,32 | 1 | ,32 | ,25 | ,61 |
| | | | Difference | 2471,87 | 23 | 107,47 | 84,39 | ,00 |
| | Intra-group | | | 63,67 | 50 | 1,27 | | |
| | Total | | | 2535,87 | 74 | | | |
| TP | Inter-group | (Combined) | | 372,15 | 24 | 15,50 | 7,20 | ,00 |
| | | Linear term | Contrast | 35,02 | 1 | 35,02 | 16,28 | ,00 |
| | | | Difference | 337,12 | 23 | 14,65 | 6,81 | ,00 |
| | Intra-group | | | 107,54 | 50 | 2,15 | | |
| | Total | | | 479,69 | 74 | | | |
| lac | Inter-group | (Combined) | | 927,43 | 24 | 38,64 | 8,61 | ,00 |
| | | Linear term | Contrast | 131,72 | 1 | 131,72 | 29,34 | ,00 |
| | | | Difference | 795,71 | 23 | 34,59 | 7,70 | ,00 |
| | Intra-group | | | 224,41 | 50 | 4,48 | | |
| | Total | | | 1151,85 | 74 | | | |
| Min | Inter-group | (Combined) | | 18,96 | 24 | ,79 | ,80 | ,71 |
| | | Linear term | Contrast | 6,83 | 1 | 6,83 | 6,94 | ,01 |
| | | | Difference | 12,12 | 23 | ,52 | ,53 | ,94 |
| | Intra-group | | | 49,23 | 50 | ,98 | | |
| | Total | | | 68,19 | 74 | | | |

MG: fat content; TP protin content; lac: lactose; Fpp: freezing point; Min: minerals; ddl: degree of freedom

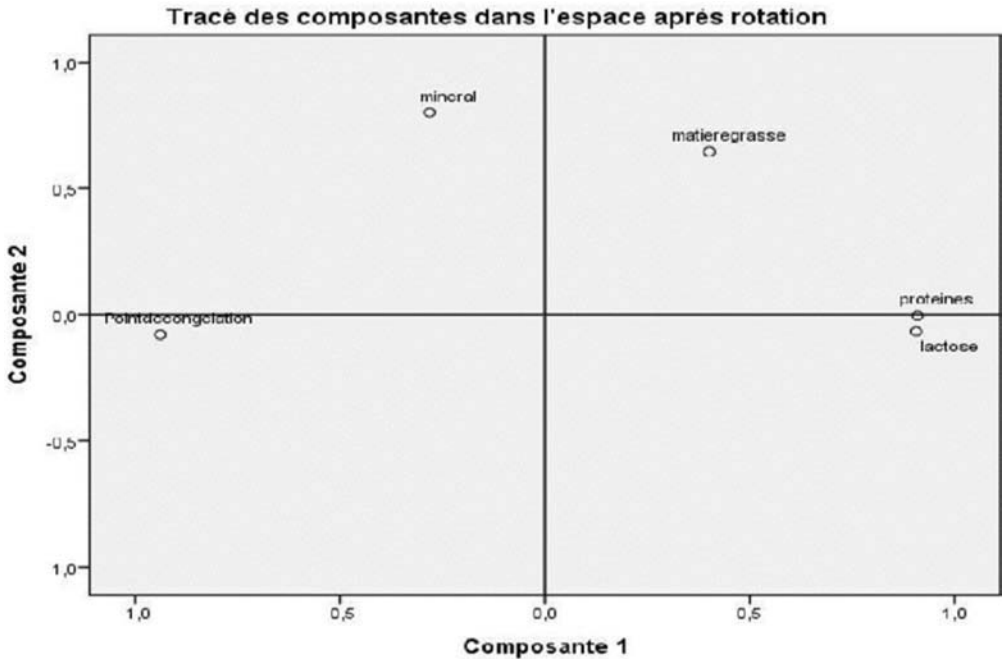



**Fig 1.** Distribution of milk quality variables on axes F1 and F2 of the ACP.

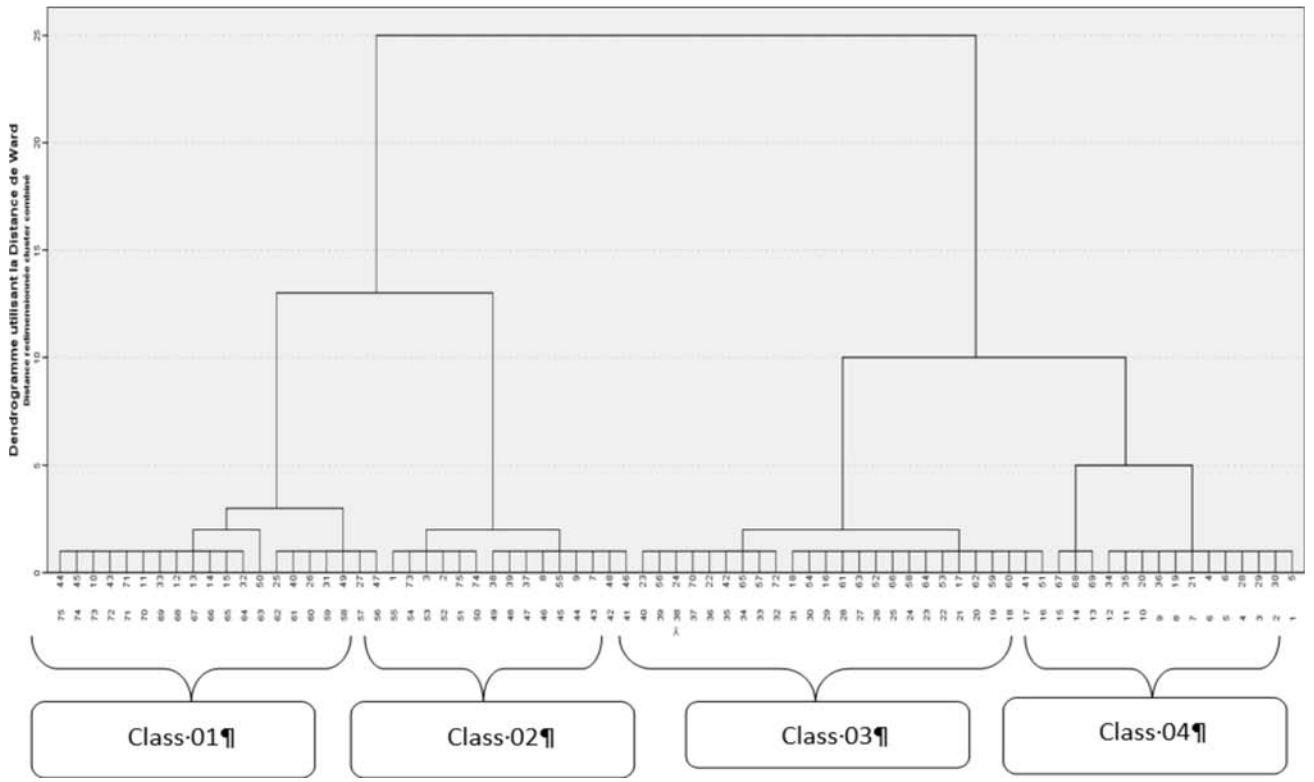



**Fig 2.** Dendogram of the automatic classification of milk samples.

the form of protein nitrogen (90% of total nitrogen). Camel milk contains more free amino acids and other non-protein nitrogen compounds (NPN) than bovine milk (Atarhouch *et al*, 1997). Protein content varies depending on the stage of lactation. The first two months of lactation are characterised by a decrease in protein and fat levels in camel milk.. According to Musaad *et al* (2013), the protein content of camel milk varies significantly depending on the stage of lactation and the season. It tends to increase at the end of lactation, while seasonal variations are also observed, reflecting the influence of physiological and

environmental conditions on the protein composition of camel milk.

The average lactose content of the camel milk samples analysed was 47.28g/l ±3.94. The lactose concentration of camel milk is close to the values reported by several authors: Mehaia *et al* (1995), Gorban and Izzeldine (1997), Gnan and Sheriha (1986) in Libya (56 g/l), Desal *et al* (1982) (42 g/l) and Sboui *et al* (2016) (42.78g/l). The lactose content of milk is one of the most stable parameters, except in the case of extreme dietary change. Its concentration remains unchanged regardless of the season (Haddadin and al, 2008) or the animal's state of hydration, whether hydrated or dehydrated (Yagil and Etzion, 1980). According to Musaad *et al* (2013), the lactose content of camel milk shows limited variability compared to other major constituents. It is only slightly influenced by the stage of lactation and physiological variations, remaining generally stable throughout lactation. The seasonal fluctuations observed are modest and mainly reflect the animal's metabolic adaptation to environmental conditions, confirming that lactose is one of the most consistent components of camel milk.

The total amount of minerals is generally expressed as total ash. The total value of minerals is around 1 g/l and 4.9 g/l. These results are low compared to those reported by Sboui *et al* (2009) with 7.5 g/l and those reported by Siboukeur (2008) with 7.28 g/l. Our results differ from those of Konuspayeva *et al* (2009), who report an average ash content in camel milk of 0.79 ± 0.09 g/100 ml. However, these authors highlight significant variations among populations in East Africa, which corresponds to the region covered by our study. In contrast, studies conducted in Asia generally show higher concentrations for most milk constituents, with the exception of ash, probably due to the predominance of Bactrian camels in this region.

The mineral content of camel milk decreases in case of water deprivation (Yagil, 1985). It also varies according to the stage of lactation (Farah, 1993). The minerals present in camel milk are key compounds that explain its beneficial effects on human health. However, data on the influence of camel nutrition on the mineral content of their milk remain limited (Konuspayeva *et al*, 2022). These observations suggest that the mineral composition of camel milk is the result of multiple interdependent factors, requiring an integrative approach to elucidate its determinants.

### *Comparative analysis of milk composition*

The comparison of camel milk samples in the study region led us to carry out a one-factor analysis of variance (Table 3). The results of the analysis of variance showed that at the 5% threshold, there are significant variations between the milk samples and which are mainly due to fat content (MF), protein content (TP), lactose content (lac). These marked differences between samples also confirm the direct consequences of breeding practices, mainly feeding. The variations observed between samples are mainly attributable to farming practices, particularly feeding practices, although individual factors such as stage of lactation may also influence the results. Overall, feeding appears to be the major determinant of camel milk quality, as indicated by the descriptive analysis of the analytical data obtained..

In fact, milk from farmers offering a ration rich in concentrates and alfalfa (20% of the farms studied) was characterised by a high protein content. On the other hand, samples of milk from farmers who graze on different pastures and do not supplement their rations (12% of farms) show low protein levels.

Although the study took place in spring, a period of good feed availability, some samples (particularly from Taibet and central Touggourt) showed low fat levels, likely because the majority of the camels were primiparous. It is well known that camel milk is lower in fat and protein after the first births, with a peak between the third and fifth lactations. Furthermore, 20% of the samples had a high fat content (40 to 45.5 g/l), which is explained by a quality diet and camels in 3rd lactation.

### *Typology of raw milk samples collected*

The first two factorial axes of the PCA on the milk composition data account for 76.83% of the total variability (Table 5 and Fig 1). Axis 1 explains 55.41% of the total variation and is considered to represent the protein level and lactose content while axis 2 represents 21.41% of the total variation and is related to the variables fat level and mineral content.

**Table 4.** Eigenvalues of the factorial axes of the PCA.

| Component | Initial eigen values | | |
|---|---|---|---|
| | Total | % of variance | Cumulative % |
| 1 | 2,771 | 55,41 | 55,41 |
| 2 | 1,071 | 21,41 | 76,83 |

### *Hierarchical Ascending Classification*

The analysis was followed by a Hierarchical Ascending Classification (HAC) on the PCA results.

**Table 5.** Characteristics of the different classes of milk identified.

| | Class01 (n=20) | Class 02 (n=15) | Class03 (n=25) | Class04 (n=15) |
|---|---|---|---|---|
| MG ( g/L) | 32,68±2.56 | 27.14±1.69 | 35.62±1.98 | 43.72±2.61 |
| Lactose (g/l) | 42.27±2.64 | 49.53±2.12 | 48.50±1.27 | 49.67±3.92 |
| MP ( g/L) | 32.95±2.02 | 34.21±1.44 | 33.88±1.477 | 34.9±2.36 |
| Minerals (g/l) | 3.57±0.98 | 2.88±0.86 | 2.93±0.853 | 3.35±1.05 |
| FPP(°C) | -0.51±0.03 | -0.56±0.02 | -0.55±0.01 | -0.58±1.54 |

MG: fat content, Lactose: Lactose content, MP: Protein content, FPP: freezing point, Results are expressed as mean ± standard deviation.

Four classes of milk can be identified (Fig 2). The general characteristics of the four identified groups are in the following (Table 6).

**- Class 1 "milk class with the highest mineral content, average protein, lactose and fat content" (n=20).** They are characterised by an average protein content (32.95g/L), lactose (42.27g/l) and fat (32.68g/L). The highest mineral content 3.57g/l, is associated with the lowest freezing point (-0.51°C). The freezing point value observed in our samples is similar to that reported by Konuspayeva *et al* (2023), who obtained −0.523 ± 0.064 °C from 736 samples analysed using the Express method (Milkoscan FT1).

**- Class 2 "milks with the lowest fat and mineral contents, associated with high protein and lactose contents" (n=15).** Its main characteristics are the lowest fat (27.14) and mineral (2.88g/l) contents, high protein (34.21g/l) and lactose (49.53g/l) contents. The milk samples in this class are characterised by a medium freezing point (-0.56°C).

**- Class 3 "milks with high protein, fat and lactose contents associated with a low mineral content" (n=25).** These milk samples are distinguished by high contents of useful materials: protein (33.88 g/l), fat 35.62 g/L and lactose 48.50 g/l, associated with a low mineral content (2.93 g/l).

**-Class 4 "milks with the highest protein, fat and lactose content and with a high mineral content."(n=15).** The milk samples in this class are characterised by the highest protein and lactose contents, respectively 34.95g/L, 49.67g/L and 43.72g/L, associated with a high mineral content (3.35g/L).

Multidimensional statistical analyses made it possible to characterise the milk samples according to the main variables reflecting milk quality: the content of useful matter. Although the differences in Figs within the different classes are rather small due to the fact that the information collected only tendentiously reflects the situation (without monitoring of farms, it remains difficult to make quantifications according to breeders), we can therefore make the following observations through the definition of the classes:

- The distribution of camel milk samples in the different classes confirms the irregularity of the quality of camel milk produced in the study region.

- The four classes resulting from the class analysis are distinguished essentially by the content of useful matter, essentially that of fat and mineral matter.

- a class of milk deserves particular attention: class 4, on the other hand, has the most favorable characteristics (satisfactory butterfat protein content and mineral content).

- The typology of milk samples made it possible to draw up a descriptive diagram of the diversity of variations that milk can undergo in a breeding environment based on variations in the content of useful materials which also confirms the direct consequences of breeding practices on the quality of milk.

## Conclusion

Through this study, we attempted to make a contribution to a better understanding and characterisation of camel milk produced in southern Algeria, in the case of the Touggourt region of the Sahraoui breed, the most abundant. The results of the physicochemical analyses indicate that camel milk has satisfactory characteristics overall. The typology of the milk samples made it possible to define four milk classes reflecting the variations that camel milk can undergo in a breeding environment based on variations in useful matter content. The distribution of milk samples in the different classes confirms the irregularity of the quality of the milk produced by the different camel herders in the study area. Only one milk class deserves special attention: class 4 having the most favorable characteristics and the highest in relation to the satisfactory fat, protein and mineral content.

## References


Abdalla E B, Ashmawy A E H, Farouk M H and al. Milk production potential in Maghrebi she-camels. Small Ruminant Research. 2015; 123:129-135.

Abu-Tarboush H.M. Compairison of associative growth and proteolytic activity of yogurt starters in whole milk from camels and cows. Journal of Dairy Science. 1996; 79(3):366-371.

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

Al haj OA, Altooq NJ, Alenezi AF and al. Camel milk composition by breed, season, publication year, and country: A global systematic review, meta-analysis, and meta-regression. Comprehensive Reviews in Food Science and Food Safety. 2022; 21(3):2520-2559.

Atarhouch T, Bendahman N, Hamers-Casterman C and al. cDNA sequen ce coding for the constant region of the dromedary gamma3 heavy Chain antibody. Journal of Camel Practice and Research. 1997; 4:177-182

Ayadi M, Hammadi M, Khorchani T and al. 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

Bedda H, Adamou A, Bouammar B and al. Le déclin des systèmes de production camelins dans le Sahara septentrional algérien - cas de la cuvette de Ouargla, le M'zab et le Ziban. Livestock Research for Rural Development, Volume 31, Article #44. Retrieved June 1, 2019, from http://www.lrrd.org/lrrd31/3/bedda31044.html

Bouras O, Aïssaoui-Zitoun O, Benyahia FA, Djeghim F and Zidoune MN. Optimisation of flocculation and clotting time of camel milk with camel and goat rennets, and chicken pepsin in comparison with cow milk using response surface method (RSM). Emirates Journal of Food and Agriculture. 34(7):575-585, doi: 10.9755/ejfa.2022.v34.i7.2881.

Desal H K, Patel JN and Pandya AJ. Composition of camel milk. Gujarat Agricultural Universities Research Journal. 1982; pp 131-132.

Elhosseny M, Gwida M, Elsherbini M, Samra RA and Ashmawy MA. Evaluation of physicochemical properties and microbiological quality of camel milk from Egypt. Journal of Dairy, Veterinary and Animal Research. 2018; 7(3):92-97. DOI: 10.15406/jdvar.2018.09.00197.

Ellouze S and Kmmoune M. Evolution de la composition du lait de dromadaire en fonction du stade de lactation. Options Méditerranéennes. 1989; 6:307-323.

FAO. Camels and Camel Milk. FAO Animal Production and Health Papers: Rome. 1982; pp 41

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

Farah Z and Ruegg MW. The size distribution of casein micelles in camel milk. Food Structure. 1989; 8(2):6.

Fguiri I, Ziadi M, Rekaya K, Samira A and Khorchani T. Isolation and characterisation of lactic acid bacteria strains f rom raw camel milk for potential use in the production of yogurt. Journal of Food Science & Nutrition. 2017; 3:1-8

Gnan SO, Mohamed MO, Shereha AM and al. Fermentation ability of camel's milk. Actes du colloque: Dromadaires et chameaux animaux laitiers. 1994; 24-26 Octobre, Nouakchott, Mauritanie

Gnan SO, Sheriha AM. Composition Libyan camel milk. Australian Journal of Dairy Technology. 1986; 41:33-35.

Gorban AM and Izzeldi OM. Mineral content of camel milk and colostrum. Journal of Dairy Research. 1997; 64(3):471-474.

Gorban AM and Izzeldin OM. Fatty and lipids of camel milk and colostrum. International Journal of Food Science and Nutrition. 2001; 52:283-287.

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

Kamal AM, Salama OA and El-Saied KM. Changes in the amino acid profile of camel milk protein during early lactation. International Journal of Dairy Science. 2007; 2(3):226–234

Kamoun M. Evolution de la composition du lait de dromadaire durant la lactation : conséquences technologiques. In : Actes du Colloque « Dromadaires et chameaux animaux laitiers », 24-26-octobre 1994, Nouakchott, Mauritanie

Karue CN. The dairy Characteristics of Kenyan Camel. Actes du colloque: "Dromadaires et chameaux animaux laitiers », 24-26 Octobre1994, Nouakchott, Mauritanie.

Kaskous S. Camel milk composition, udder health and effect of different storage times and temperatures on raw milk quality using camel milking machine "StimuLactor". Agriculture and Food Sciences Research. 2019; 6(2):172-181

Konuspayeva Gaukhar, Al-Gedan Mubarak M. Alzuraiq Fuad and al. Some Variation Factors of Freezing Point in Camel Milk. Animals. 2023; 13:1657. https://doi.org/10.3390/ani13101657.

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; 22:95-101.

Konuspayeva Gaukhar, Faye Bernard, and Bengoumi Mohammed. Mineral status in camel milk: a critical review. Animal Frontiers. 2022; 12(4):52-60.

Mahboub N. Contribution à l'amélioration de la fromageabilité du lait camelin: Etude des conditions de conservation des enzymes gastriques camelines (type présure); Mémoire de magister en biochimie et analyse des bioproduits; Université Kasdi Merbah Ourgla. 2010.

Mehaia MA. Fresh soft white cheese (Domiati type) from camel milk; composition, yield and sensory evaluation. Journal of Dairy Science. 1993; 6:2845-2855.

Mehaïa MA, Hablas MA, Abdel-Rahim KM and al. Milk composition, Wada and Hamra camels in Saudi Arabia. Food Chemistry. 1995; 52:115-122

Mohamed MA, Mursal AI and Larsson-Raznikiewicz M. Separation of camel milk casein fraction and its

relation to the coagulation properties of fresh milk. Milchwissenschaft. 1989; 44(5):278-280.

Musaad AM, Faye B, Al Mutairi SE *et al*. Variation saisonnière et physiologique de la composition brute du lait de chamelle en Arabie saoudite. Emirates Journal of Food and Agriculture. 2013; 25(8):618-624 doi: 10.9755/ejfa.v25i8.16095

Nagy P, Fábri ZN, Varga L *et al*. 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

Ramet JP. Les aspects scientifiques et technologiques particuliers de la fabrication des fromages au lait de dromadaire Comm. Coll. Dromadaires et chameaux: animaux laitiers. 1994; Nouakchott, Mauritania

Saley M. La production laitière du dromadaire. Maisons-Alfort : CIRAD-EMVT. Mémoire DESS (Synthèse bibliographique) : Productions Animales en Régions Chaudes : Ecole nationale vétérinaire d'Alfort. 1993; pp 34.

Sboui A, Djegham M, Belhadj O and al. Le lait de chamelle: qualités nutritives et effet sur les variations de la glycémie. In : Napoléone M. (ed.), Ben Salem H. (ed.), Boutonnet J.P. (ed.), López-Francos A. (ed.), Gabiña D. (ed.). The value chains of Mediterranean sheep and goat products. Organisation of the industry, marketing strategies, feeding and production systems. Zaragoza : CIHEAM. 2016; 487-492 (Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 115).

Sboui A, Khorchani T, Djegham M and al. Comparaison de la composition physico-chimique du lait camelin et bovin du Sud Tunisien; variation du pH et de l'acidité à différentes températures. Afrique Science. 2009; 5 (2):293-304

Sharma R. Chemical and Microbiological Analysis of Milk and Milk Products. International Book Distributing Company, Pub. Division. Co, India. 2006; pp 9-33.

Siboukeur Om. Etude du lait camelin collecté localement : caractéristiques physico-chimiques et microbiologiques; aptitudes à la coagulation. Thèse de doctorat en Sciences Agronomiques, option : Sciences Alimentaires de l'Institut National Agronomique El-Harrach – Alger (Algérie). 2008; pp 135.

Sodini I, Lucas A, Oliveria MN and al. Effect of milk base and starter culture on acidification, texture and probiotics cell counts in fermented milk processing. Journal of Dairy Science. 2002; 85(10):2479-2488

Yagil R. Camels and Camel Milk. FAO. Animal Production and Health. 1985; Paper n° 26:1-69

Yagil R and Etzion Z. Effect of drought conditions on the quality of camel milk. Journal of Dairy Research. 1980; 47:159-166.

DOI : 10.5958/2277-8934.2026.00008.5 Vol 33 No 1, p 59-66

# HISTOCHEMISTRY, THE PRESENCE OF CARBOHYDRATES, ALKALINE AND ACID PHOSPHATASE ENZYMES, IN THE ADRENAL GLAND TISSUE DURING PRENATAL DEVELOPMENT IN DROMEDARY CAMEL

**Hidaia. B. Zolain[1,3] and Dafa alla. I. Osman[2]**

[1]Department of Anatomy, Faculty of Veterinary Medicine, King Fiasal University, Saudi Arabia
[2] Department of Anatomy, Faculty of Veterinary Medicine, University of Khartoum, Sudan
[3]Department of Anatomy, Faculty of Veterinary Science, University of Nyala, Sudan

## ABSTRACT

The current study's goals are to investigate the foetal adrenal gland's histochemistry. Twenty-five foetuses at various developmental stages were used for conventional histological and histochemical techniques. Alkaline phosphatase activity was discovered in the same locations as PAS positive diastase-digested material. Neuroblasts, blood vessels, the adrenal capsule, the cells of the zona glomerulosa, the innermost part of the zona fasiculata and the foetal zone were all shown to have both alkaline phosphatase and PAS positive diastase resistant material. The blood vessels and a few isolated cells in the cortex and medulla were found to have the enzyme acid phosphatase. In conclusion, although it has unique characteristics, the histochemistry of the developing camel foetal adrenal gland was generally comparable to that of the foetal adrenal glands of other domestic animals.

**Key words:** Adrenal gland tissue, alkaline and acid phosphatase, camel, histochemistry, prenatal development

One of the most crucial endocrine organs for survival is the adrenal glands (Bielohuby, 2007). The adrenal cortex and the adrenal medulla are two distinct organs with distinct origins, roles and physical traits that come together during embryonic development. They originate from many germ layers. The coelomic epithelium gives rise to the cortex, while the neural gives rise to sympathetic ganglion cells which is the source of medulla cells (Dudek, 2011; Kim *et al,* 2009).

The function of the adrenal glands is crucial throughout foetal development. In order for the liver, lung, thyroid gland and gut to functionally mature and prepare for life outside the uterus, the foetal adrenal gland is essential for maintaining intrauterine homeostasis (Liggins, 1976).

The present study was therefore planned to investigate the histochemistry of the adrenal gland's constituents (enzymes and carbohydrates).

## Materials and Methods

The adrenal gland was collected in the present study from 25 foetuses at different stages of development.

Small pieces of tissue up to 3 mm thick were fixed for 24 hours in cold (-4°C) acetone for paraffin processing method and then dehydrated with acetone at room temperature (two changes, each change for 1 hour), cleared in two changes of chloroform for half to one hour each, impregnated with paraffin wax at (56°C) for 15 -30 minutes in the vacuum oven, sectioned at 5µ, flattened on luke warm water bath and mounted on albumenised slides.

### Carbohydrates

#### *PAS positive diastase digested material (glycogen)*

For detection of glycogen, the tissues were fixed either in the cold gender fluid (saturated aqua's picric acid in 95% ethanol, glacial acetic acid and formalin) for about 4 hours (Culling,1974) or in formal saline. After the routine processing, the sections were stained with PAS (periodic acid with Schiff reagent).

#### *PAS positive diastase resistant material*

For mucopolysachrides PAS with diastase control the sections were incubated in 1% diastase solution or saliva at 37°C, for one hour

SEND REPRINT REQUEST TO HIDAIA. B. ZOLAIN email: zolainhidaia@gmail.com

for the differentiation between glycogen and mucopolysachrides.

**Enzymes**

*Alkaline phosphatase*

Alkaline phosphatase was detected using Gomori's calcium phosphate technique (Culling, 1974; Durary and Wallington, 1980). This method involved incubating the sections in the substrate for 3 to 6 hours, washing them in distilled water, putting them in an aqueous solution of cobalt nitrate for 5 minutes, then moving them to a fresh 1% solution of yellow ammonium sulphide for 1 minute, washing them under running water, counter-staining them with 0.1% safranin in 0.1% acetic acid, dehydrating, clearing and mounting them in a synthetic medium.

*Acid phosphatase*

The lead nitrate method (modified from Gomori, 1950) was used and it consisted of 0.05 acetate buffer at PH (5) and 0.53g lead nitrate and 3% solution of sodium β glecrophosphate. Sections were incubated in the prepared solution for one hour, washed briefly and transferred to 1% ammonium sulphide for 1-2 minutes, washed and counterstained with 1% aquous eosin followed by washing in tap water and then in distilled water and mounted in glycerol jelly.

**Results**

***1.PAS positive diastase digested material (Glycogen)***

*First trimester*

During the early stage of the first trimester, a strong reaction for PAS was found in the blood vessels, in the accumulation of cells which formed the primordia of the adrenal cortex and in the migrating neuroblasts. In the middle stage of the first trimester, the reaction was found in the boundary tissue of the adrenal cortex and a moderate reaction in the capsule and the foetal zone but the zona fasciculata showed weak or negative reaction. The reaction was observed in the neuroplasts, blood vessels and nerve fibres in the developing medulla.

*Second trimester*

The developing trabeculae as well as the capsule and subcapsular artery plexus showed a significant reactivity in the early stages of the second trimester. The chromaffin cells had moderate to strong reactions, the developing zona fasciculata showed weak reactions, the foetal zone and medulla showed strong reactions and as people aged, the zona glomerulosa, blood vessels and nerve fibres also showed strong reactions (Fig 2 and 3).

*Third trimester*

The developing trabeculae as well as the capsule and subcapsular artery plexus showed a significant reactivity in the early stages of the second trimester. The chromaffin cells had moderate to strong reactions, the developing zona fasciculata showed weak reactions, the foetal zone and medulla showed strong reactions and as the developing age, the zona glomerulosa, blood vessels and nerve fibres also showed strong reactions.

***PAS positive diastase resistant material (Mucopolysacchrides)***

*First trimester*

The accumulation of cells from the primordia of the adrenal cortex, the capsule and the blood vessels showed a mild reactivity to the diastase-resistant substance. The foetal zone had a weak to moderate reactivity, but the medulla, with the exception of the blood vessels, displayed a negative reaction.

*Second trimester*

The zona fasciculata displayed a negative reaction, whereas the capsule, trabeculae, zona glomerulosa, blood vessels, nerve fibres and chromaffin cells displayed a faint response (Fig 6).

In general, the response was intensified as compared to the previous periods. The zona fasciculata displayed a negative reaction, whilst the capsule and trabeculae displayed a moderate response. Chromaffin cells, blood arteries and nerve fibres, all responded favourably (Fig 7 and 8).

**2. Enzymes**

***1. Alkaline phosphatase***

*First trimester*

The migrating neuroblasts in the mesentery and adrenal tissue demonstrated a strong positive response to alkaline phosphatase activity during the early stages of development, as did blood vessels. The cells in the foetal zone displayed a moderate response (Figs 9 and 10).

*Second trimester*

The growing zona glomerulosa, the blood vessels and the vascular plexus of the subcapsular area, all showed a significant response. Alkaline phosphatase also demonstrated a robust positive

reaction on the capsule's exterior. The zona fasciculata's innermost portion displayed a moderate to strong reactivity for alkaline phosphatase, but its outermost part displayed a faint positive reaction. With the exception of nerve fibres and blood vessels, which demonstrated a significant reactivity to alkaline phosphatase, the medullary tissue had a mild to negative reaction (Fig 11).

### *Third trimester*

Alkaline phosphatase activity was strongly positive in the zone glomerulosa. Alkaline phosphatase also showed a robust positive reaction in the blood vessels, nerve fibres and septae boundaries (Fig 12).

Alkaline phosphatase exhibited a moderate reaction in the zona fasciculata's outermost section and a weak to negative reaction in its innermost part. The alkaline phosphatase reaction was mild in the foetal zone and strongly positive in the sinusoids and nerve fibres (Fig 13).

**Table 1.** Illustrates the degree of alkaline phosphatase reaction in diferent foetal adrenal gland components throw gestation period.

| Zone | Gestation period | | |
|---|---|---|---|
| | FIRST | SECOND | THIRD |
| Foetal zone | +++ | ++ | ++ |
| Innermost region of zona fasciculata | – | ++ | + |
| Outermost region of zona fasciculata | – | + | ++ |
| Zona glomerulosa | _ _ | +++ | +++ |
| Capsule | ± | ++ | ++ |
| Medulla | __ | ± | ± |
| Hilus | +++ | +++ | +++ |
| Blood vessel in general | +++ | +++ | +++ |
| Nerves fibres in general | +++ | +++ | +++ |

Key of table: +++ strong, ++ moderate, + weak, ± weak to absence, _negative.

### *2. Acid phosphatase*

With the exception of blood vessels and a few isolated cells that displayed a mild reaction, the adrenal gland tissue during the three trimesters had a negative reaction for the acid phosphatase enzyme (Fig 14).

## Discussion

Goats' adrenal capsule and parenchyma were PAS positive starting on day 42 of pregnancy and the reaction's intensity increase as the foetus grew older (Fowden *et al,* 1998; Ashoke *et al,* 2011). The current study supported earlier findings that a substantial reactivity to PAS was shown in the blood vessels, in the migration of neuroblasts and in the accumulation of cells that formed the primordia of the adrenal cortex in the early stages of the first trimester. According to Bielanska-Osuchowska (1989), the developing cells of the zona glomerulosa, as well as the cortical and medullary cells, were mildly positive for PAS in the foetal pig. These reports are consistent with the current study.

The zona reticularis, trabeculae and capsule of a full-term goat foetus were all highly PAS positive. The zona fasciculata and medulla had a moderate reaction, but the zona glomerulosa displayed a modest reactivity (Ashoke *et al,* 2011). The current study also showed that the capsule, subcapsular vascular plexus and developing trabeculae all exhibited robust reactions in the early stages of the second trimester. The foetal zone exhibited a significant reaction, whereas the growing zona fasciculata displayed a modest reaction.

According to Ashoke *et al* (2011), the acid mucopolysaccharide reaction in goat foetuses was first observed once they were 73 days old and it was weak in the cortical cells and moderate in the capsule. The reaction was discovered earlier in the current study than in the foetal goat.

The accumulation cells of the capsule, blood arteries and primordia of the adrenal cortex showed a modest response to diastase-resistant material. With the exception of the blood vessels, the medulla displayed a negative reaction, while the foetal zone displayed a moderate response.

As foetal age increased, cortical cells exhibited a robust response to acid mucopolysaccharide, but medullary cells displayed a moderate response. In young foetuses, the cortical and medullary cells had a positive response to glycogen; however, as pregnancy progressed, the cortical cells' intensity diminished. According to Ashoke *et al* (2011), goat foetuses' future cortex cells showed a significant buildup of glycogen starting on day 122. The current study showed that as development progresses, the reactivity between glycogen and mucopolysacrides intensifies.

According to Ashoke *et al* (2011), the goat foetus's developing cortical cells exhibited robust alkaline phosphatase activity up to 84 days, moderate activity up to 122 days and further increased toward term.

These authors found that the decreased activity of alkaline phosphatase between 84 and 122 days of

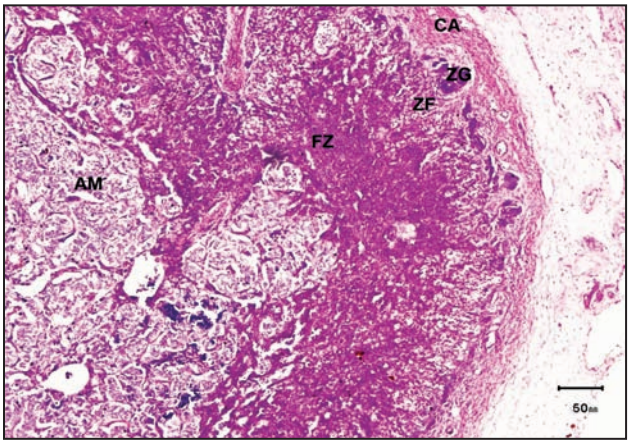



**Fig 1.** Photomicrograph illustrating a strong PAS- positive diastase digested material in foetal zone (FZ) and zona glomerulosa (ZG) while the capsule (CA), zona fasciculata (ZF) and the adrenal medulla (AM) showed moderate to weak reaction. From a foetus of 63 cm CVRL (238 days of age). PAS technique diastase digested material X 40.

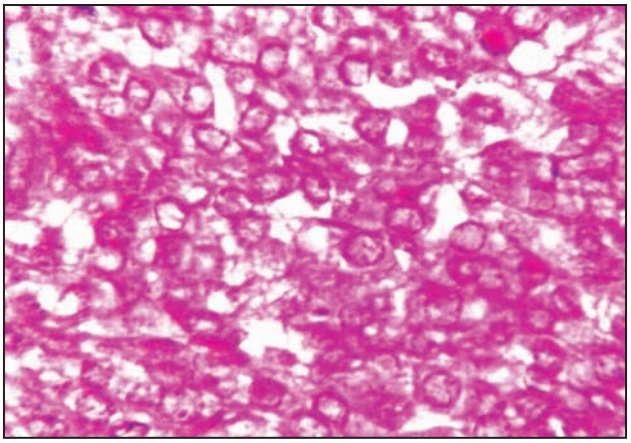


**Fig 2.** Photomicrograph showing a strong PAS- positive diastase digested material in the cells of the foetal zone from a foetus of 72 cm CVRL (262 days of age). PAS technique diastase digested material X 1000.

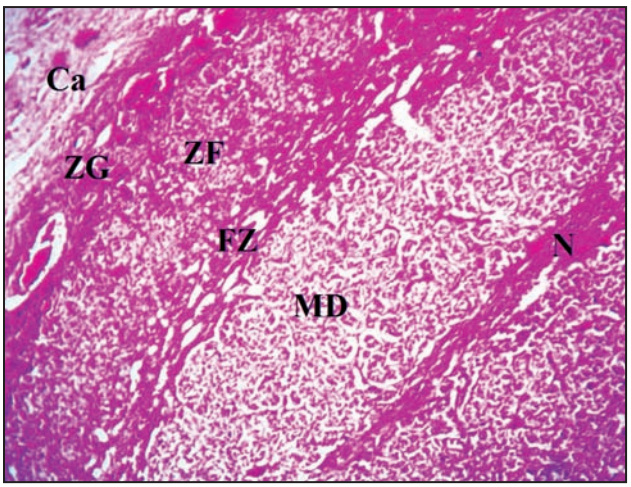



**Fig 3.** Photomicrograph from a foetus of 78 cm CVRL (278 days of age) demonstrating a strong PAS- positive diastase digested material in the zona glomerulosa (ZG)and nerve fibres within the medulla (N) while the capsule (Ca), zona fasciculata (ZF) and the adrenal medulla (MD) showed a moderate reaction. PAS technique diastase digested material. X 100.

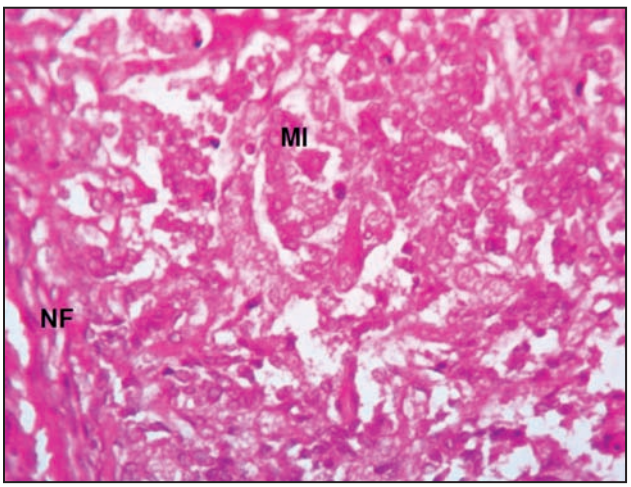



**Fig 4.** Photomicrograph demonstrating a strong PAS- positive diastase digested material in nerve fibres (NF) within the medulla, while the medullary islets (MI) showed modarate reaction. From a foetus of 78 cm CVRL (278 days of age). PAS technique diastase digested material X 400.

foetal life was caused by the cortical zones' decreased activity during this time, as seen in goats.

Similar to Bielanska-Osuchowska's (1989) findings in the foetal pig, this investigation found weak alkaline phosphatase activity in the subcapsular zone and none in the migratory cells.

Goat foetuses from 58 days to full term showed a moderate level of acid phosphatase activity in the cortical cells directly beneath the capsule. Throughout foetal development, medullary cells exhibited high levels of enzyme activity. Up to 122-day-old foetuses had very little or no enzyme activity in other cortical cells. After that, these cells showed a modest level of activity until term.

Acid phosphatase activity was generally higher in medullary cells than in cortical cells (Ashoke *et al,* 2011). According to the prenatal investigation, the camel foetal adrenal gland's blood arteries were the only places where the acid phosphatase reaction was detected.

According to Osman *et al* (1976) and Osman (1984), the alkaline phosphatase enzyme is typically found where PAS-positive diastase-resistant material may be seen and it may play a part in the movement

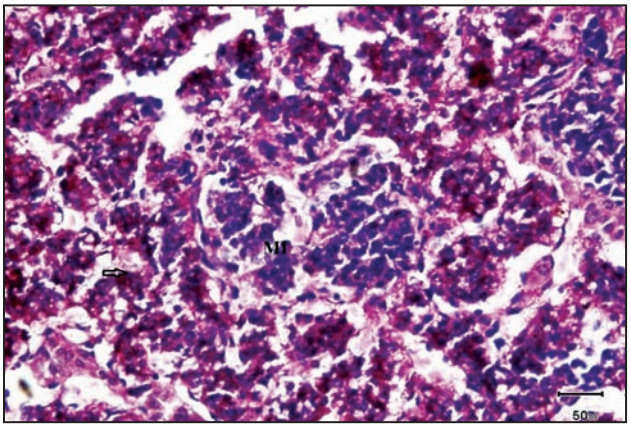



**Fig 5.** Photomicrograph from a foetus of 80 cm CVRL (260 days of age). Note the strong PAS- positive diastase digested material in the chromaffin cells(arrow) within the medulla, medullary islets (MI). PAS technique without diastase X 100.

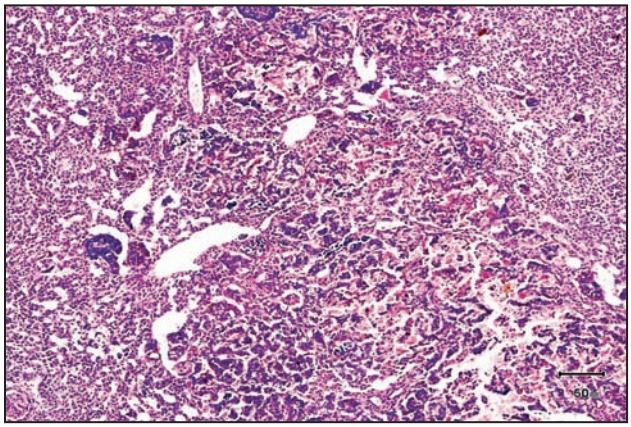



**Fig 6.** Photomicrograph illustrating a weak PAS-positive diastase resistant material in the adrenal medulla in a foetus of 40 cm CVRL (175 days of age). PAS technique with diastase, X 40.

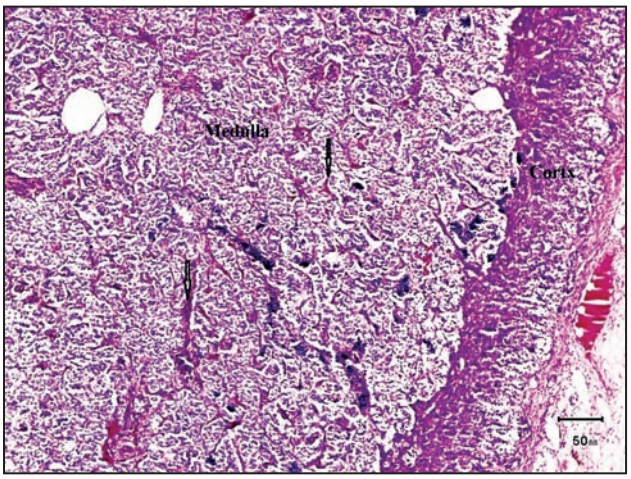



**Fig 7.** Photomicrograph demonstrating moderate PAS-positive diastase resistant material in the cortex and in the nerve fibres (arrows) and connective tissue of the adrenal medulla from a foetus of 63 cm CVRL (238 days of age). PAS technique with diastase. X 40.

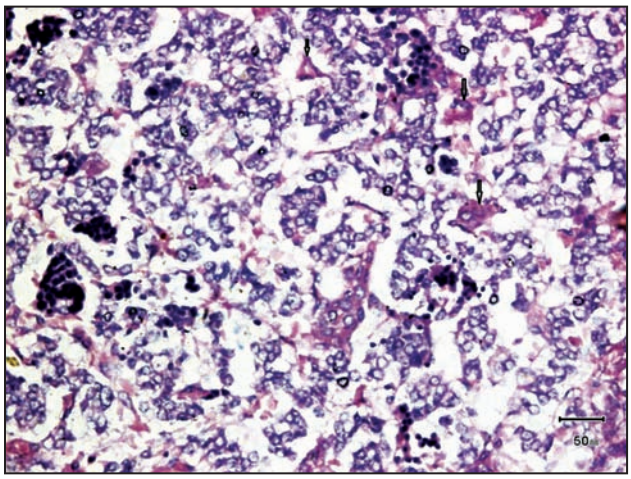



**Fig 8.** Photomicrograph demonstrating a weak PAS-positive diastase resistant material in the adrenal medulla in general but a moderate reaction was found in the gangiloin cells (arrows) of a foetus of 75 cm CVRL (270 days of age). PAS technique with diastase, X 100.

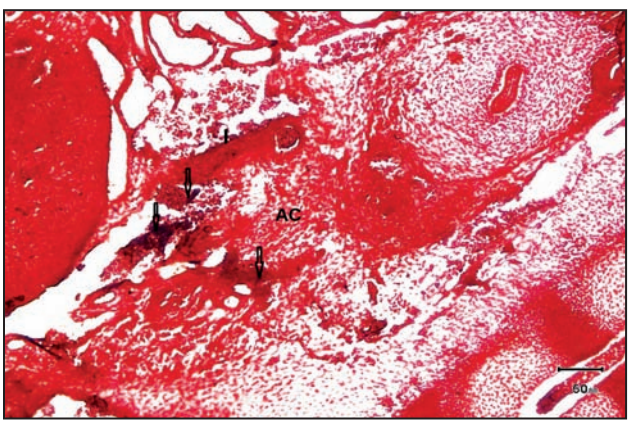



**Fig 9.** Photomicrograph showing a strong alkaline phosphatase activity in the primordia of the adrenal cortex (AC) (arrows) in a foetus of 2 cm CVRL (71 days of age). Gomori and Lillie technique, X40.

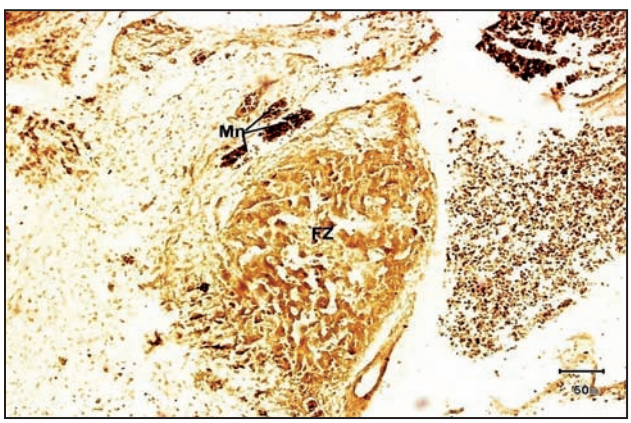



**Fig 10.** Photomicrograph demonstrating a strong alkaline phosphatase activity in the migrating neuroblasts (Mn) and moderate reaction in the foetal zone (FZ) of the adrenal cortex in a foetus of 5.6 cm CVRL (80.8 days of age). Gomori and Lillie technique, X40.

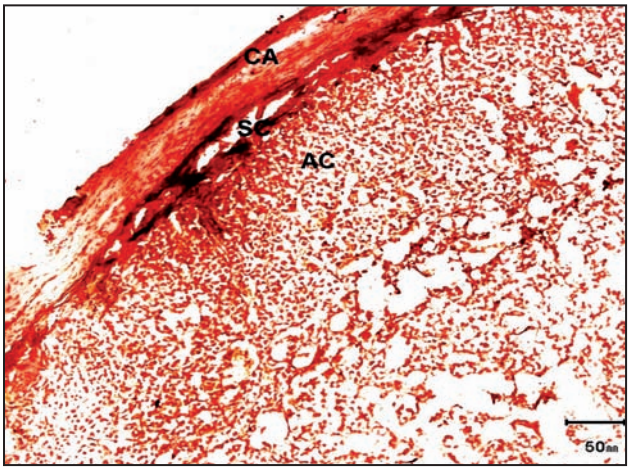



**Fig 11.** Photomicrograph illustrating a strong alkaline phosphatase activity (Black colour) in the Adrenal capsule (CA) and sub capsular arterial plexus (SC). AC: adrenal cortex in a foetus of 65 cm CVRL (243 days of age). Gomori and Lillie technique, X100.

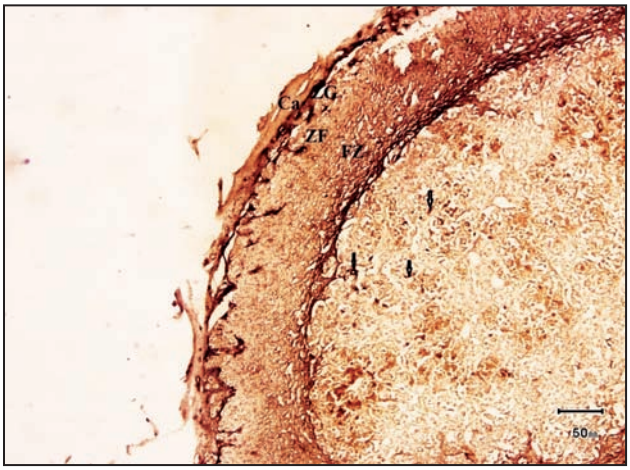



**Fig 12.** Photomicrograph showing a strong alkaline phosphatase activity in the capsule (Ca), zona glomerulosa, (ZG) and foetal zone (FZ) (black colour) and a moderate reaction was found in the medulla (arrows) in a foetus of 92 cm CVRL (317 days of age). Gomori and Lillie technique, X100.

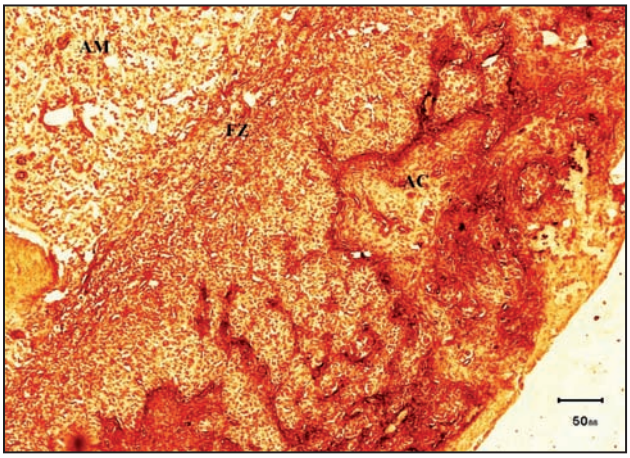



**Fig 13.** Photomicrograph demonstrating a strong alkaline phosphatase activity in adrenal cortex (AC) (brown to black colour), moderate in the foetal zone (FZ) and week in the adrenal medulla (AM) from a foetus of 101 cm CVRL (342 days of age). Gomori and Lillie technique, X100.

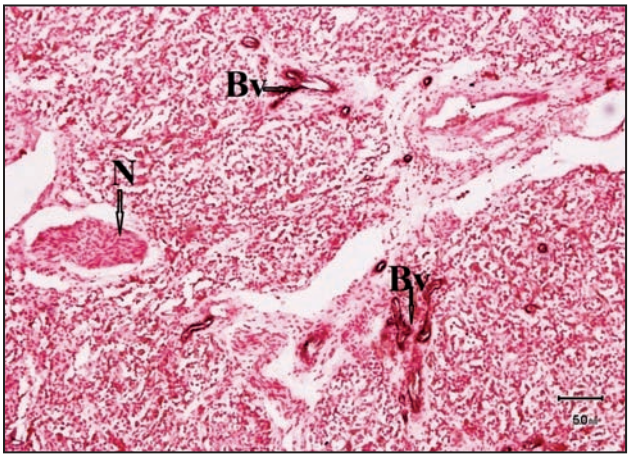



**Fig 14.** Photomicrograph illustrating a strong acid phosphatase activity in the medullary blood vessels (BV) while the nerve fibres (N) showed negative reaction from a foetus of 78 cm CVRL (278 days of age). Gomori and Lillie technique, X40.

of substances. According to Verma and Guraya (1967), alkaline phosphatase activity locations are highly vascularised, suggesting a direct physiological link between the enzyme and organ component blood vascularity.

Alkaline phosphatase therefore plays a crucial role in facilitating the transport of materials across the cellular membranes in the vertebrate's ovaries and may be involved in the transfer of nutrients, secretary materials, or waste products across the cellular membranes of blood vessels and surrounding tissues. The findings of the aforementioned writers are consistent with the current investigation.

It was opined that the activity of the acid phosphatase enzyme in individual germ cells can be caused by the cell's apoptotic process.

## Conclusion

Glycogen was found in the blood vessels, in the accumulation of cells which formed the primordia of the adrenal cortex and in the migrating neuroblasts. In the middle stage of the first trimester, the reaction was found in the boundary tissue of the adrenal cortex, moderate reaction in the capsule and the foetal zone but zona fasciculata showed weak or negative reaction. In the developing medulla, the reaction was

found in the nerve fibres, blood vessels and in the cytoplasm of the neuroplasts.

- A weak reaction of the diastase resistant material was found in the accumulation of cells of the primordia of the adrenal cortex, the capsule and blood vessels in the foetal zone. The medulla showed negative reaction except in the blood vessels. During the second and third trimesters, the capsule, trabeculae, zona glomerulosa, blood vessels, nerve fibres and chromaffin cells showed a weak reaction, while the zona fasciculata showed a negative reaction.
- During the first trimester, the neuroblasts and the blood vessels showed a strong positive reaction for alkaline phosphatase, while the cells of the foetal zone showed a moderate reaction. During the second and third trimesters, a strong reaction was found in the developing zona glomerulosa, the blood vessels and in the arterial plexus and the outer surface of the capsule. The outermost region of the zona fasciculata showed a weak positive reaction while the innermost region of zona fasciculata showed moderate to strong reaction for alkaline phosphatase.
- The medullary tissue showed a weak to negative reaction for alkaline phosphatase except the nerve fibres and the blood vessels which showed a strong reaction for alkaline phosphatase.
- The acid phosphatase activity was absent in the developing adrenal glands during the different stages of development except in the blood vessels and in sporadic cells in the cortex and medulla.


## Acknowledgements

Authors thank the technical staff of the Department of Anatomy, King Faisal University and University of Khartoum for their assistance in the laboratory work.


## Ethical Statement

This study was done according to the guidelines of the Declaration of Helsinki.

## Data Availability

The data generated during the study can be requested from the corresponding author.

## Conflict of Interest

The authors declare no conflict of interest.

## References


Ashoke M, Harshan KB and Chungath JJ. Histochemical studies on the developing adrenal gland in cross breed goat foetuses (*Capra hircus*). Tamil Nadu Journal of Veterinary & Animal Sciences. 2011; 7(3):193-197.

Bancroft JD and Stevens SA. Theory and Practice of Histological Techniques. 4th edition. New York. Edinburgh. 1990.

Bello A, Lawala UF, Sonfad ML, Umaru MA, Onu JE, Shehu SA and Umar AA. Histomorphometric study of the prenatal development of the kidney of one-humped camel (*Camelus dromedarius*) in north-westhern Nigeria. Scientific Journal of Zoology. 2013; 2(4):27-35.

Bielanska-Osuchowska Z. Prenatal development of the adrenal gland in pig (Sus Scrofa dom). Part II Adrenal cortex development in the second part of pregnancy. Follia Morphologica (Warsz). 1989; 48(1-4):29-58.

Bielohuby M. The mouse adrenal gland: age -and- gender-dependent alterations of growth and function. PhD Thesis. Vetrerinary Faculty of the Ludwig- Maximillians –University, Munich. 2007.

Boglione L, Bondone C, Corno E, Gastaldo L, Borghi F, Gattolin A and Levi AC. The development of the suprarenal gland: surgical and anatomical considerations. Panminerva Medica. 2001; 43(1):33-7.

Culling CFA. Handbook of Histological and Histochemical Techniques 2nd edition. Butter Woorth and Co.ltd. London. 1974.

Dudek R. Development of human the nervous system. In: Broad Review Series Embryology. 5th edition Philadelphia. 2011; pp 70-81.

Durary RAB and Wallington EA. Carleton's Histological techniques. Fifth Edition, Oxford University Press. New York Torinto. 1980.

Fowden AL, Linda M and Silver M. Developmental regulation of glucogenesis in the sheep foetus during the late gestation. Journal of Physiology. 1998; 508(3):937-947

Gomori G. The quantitative determination of histochemical reaction for enzymes. Experimental Cell Research. 1950; pp 33-36.

Kim AC, Ferddous MB, Joanne HH, Else T, Victoria RK, Krill KT, Scheys JO, Dreak PS, Alissa T, Yang H and Hammer GD. In search of adrenocortical stem and progenitor cells. Endocrine Reviews. 2009; 30(3):241-263.

Liggins GC. Adrenocortical-related maturational events in the foetus. American Journal of Obstetrics and Gynoecology. 1976; 126(7):931-941.

Liggins GC. The role of cortisol in preparing the foetus for birth. Journal of Reproduction, Fertility and Development. 1994; 6(2):141-150.

Mecenas CA, Giussani DA, Owiny JR, Jenkins SL, Wu WX, Honnebier BO, Lockwood CJ, Kong L, Guller S and Nathanielsz PW. Production of premature delivery in pregnant rhesus monkeys by androstenedione infusion. Nature Medicine. 1996; 2(4):443-448.

Musa BE. The development, presentation, position and posture of the foetus in camel (*Camelus dromedarius*). Sudan Journal of Veterinary Science and Animal Husbandry. 1979; 20(2):37-40.

Osman DI, Moniem KA and Tingari MD. Studies on the testis of the camel (*Camelus dromedarius*).III. Histochemical observation. Histochemical Journal. 1976; 8:579-590.

Osman DI. On the histochemistry of the seminiferous tubules and their terminal segments in the ram testis Zentralblatt Fur Veterinar Medicine, (C) Anatomie, Histologie Und Embryologie. 1984; 13:319-326.

Prasad G and Yadava RCP. Histological and histochemical studies on the adrenal glands of Indian buffalo. Indian Journal of Animal Sciences. 1974; 44:243-248.

Salman SF. Morphology of the ovary, endometrium and placenta of the dromedary. Ph.D. Thesis, Faculty of Veterinary Medicine, University of Khartoum. 2001.

Sckwartz HJ and Dioli M. The One Humped Camel in Eastern Africa. Verlag Josef Margraf Scientific Books. Germany. 1992.

Sibtain A, Muhammad Y, Muhammad QBl, Ghulam M, Li-Guo Y, Muhammad KK and Muhammad T. Risk factors associated with prevalence and major bacterial causes of mastitis in dromedary camels (*Camelus dromedarius*) under different production systems. Tropical Animal Health and Production. 2012; 44:107-112.

Varma SK and Guraya SS. The localisation and functional significance of alkaline phosphatase in the vertebrate ovary. Experientia. 24:398–399 (1968). https://doi.org/10.1007/BF02140844

Verma SK and Guraya. The localisation and functional significance of alkaline phosphatase in the vertebrate ovary. Cellular and Molecular Life Sciences. 1967; 24(4):398-399.

Wardeh MF. Classification of the dromedary camel. The Camel Applied Research and Developmental Network. (CARDN). Volume 1. No 1 JCS. 1992; (1):1-135.

DOI : 10.5958/2277-8934.2026.00009.1 Vol 33 No 1, p 67-76

# THE CHARACTERISTICS OF CAMEL GRAZED RANGELAND IN THE BUTANA PLAIN, GADARIF STATE, SUDAN

**Asma Hamed Mohamed Hamed[1], Safa Mohamed Gammer[2] and Mohamed Elamin Elimam[2]**

[1]Department of Animal Production, Faculty of Agriculture and Environmental Sciences, University of Gadarif, Gadarif, Sudan

[2]Faculty of Animal Production, University of Sinnar, Abu Naama, Sinnar State, Sudan

## ABSTRACT

Camel production is very important in the Sudan and Butana plain (BP) due to high population, reputed breeds and socioeconomic impacts. However, camel contribution to milk and meat production and the national economy is less than expected due to many obstacles. Nutrition is a main constraint for camel production as it depends mainly on rangeland, which is deteriorating for many reasons. In addition, modern nutritional concepts such as the new protein systems are not applied. Butana plain, Gadarif State is a very important camel grazing area, but there is no available information on rangeland characteristics in the area to allow better exploitation and conservation. Consequently, rangeland characteristics including plants inventory, density, frequency distribution and biomass were studied in the northern and southern areas of Butana plain, Gadarif State, Sudan using a 1x1m iron quadrate. Data was statically analysed according to the completely randomised design. Plant diversity was very high in the area and in the southern area (34 and 33 plants, respectively). The plants were in 20 families, mainly Poaceae, and all families were found in the southern area. Plants inventory, families, density and grasses and forbs frequency distribution and fresh and dry biomass varied highly between areas and month. Plants and family numbers were highest in September and least in August. Plants numbers were highest in the southern area in September and October and in the northern area in August. Plants density was higher in the southern area in all month and was highest in August and least in October in the two areas. The study demonstrated higher plants numbers, diversity, density and biomass.

**Key words:** Butana plain, Gadarif state, month, rangeland characteristics

Camels are very important in Butana plain (Darosa, 2005), but their contribution to milk and meat production and national economy is too low compared with their population due to many reasons. Nutrition is a main constraint for camel production in Butana plain, Gadarif State as they depend mainly on rangeland plants which are deteriorating due to many factors (Mohamed, 2001; Abusuwar and Darrag, 2002). In addition there are seasonal variations in feeds quantity and quality associated with rainfall (Mohamed, 2013) with serious shortages and effects on animal performance and health, especially in the dry season (Ali, 2003). Successive droughts reduced frequency distribution of high quality plants and increased invaders with low nutritive value. Information on rangeland characteristics including plants inventory, frequency distribution and biomass are important for optimum rangeland plants conservation and exploitation. These parameters are affected by many factors such as rainfall (Abusuwar and Yahia, 2010; Abusuwar *et al,* 2011; Mohamed, 2013), soil (Fdial, 2013; Elimam *et al,* 2024), and areas (Abusuwar and Yahia, 2010; Mohamed, 2013; Elimam *et al,* 2024). They are also affected by season and years (Abusuwar and Yahia, 2010) and rangeland protection (Mohamed *et al,* 2014, Abdelsalam *et al,* 2017). However, this information is not available in Butana plain, Gadarif State, Sudan. In addition modern concepts of ruminant nutrition such as the new protein systems (ARC, 1982) which are based on microbial yield and feeds rumen degradation are not applied due to lack of information. Consequently, this study was conducted to furnish vital information to improve camel nutrition and production. This paper reports information on rangeland characteristics in Butana plain, Gadarif State, Sudan.

## Materials and Methods

### *Study area*

The study described below was conducted in the northern and southern areas in Butana plain, Gadarif State, Sudan. It is a very important camel grazing area, especially in autumn. Livestock rearing

SEND REPRINT REQUEST TO MOHAMED ELAMIN ELIMAM email: mmeelimam@gmail.com

and cropping are the main occupations. The area is located at latitude 140 80′ N and longitude 340 72′ E. There are two climatic zones in Butana plain, Gadarif State with summer seasonal rains from July to October with a peak in August (Farouk and Mohamed, 1982). The semiarid zone in the north and northwest areas and average rainfall is 345- 385 mm. The wet climate zone is in the eastern and southern areas of the state with 500-900 mm average rainfall and 47°C maximum mean temperature. The northern area is in Elbutana Locality in the north of Gadarif State. The Locality is bordered by Central Gadarif Locality in the south, River Nile State in the north, Khartoum State from the west, Kassala State from the east and Gezira State from the south west. Elsubag is the Locality capital and is 174 km north of Gadarif city and 265 km east of Khartoum. The southern area is in Gadarif Locality and it is 111 km north-west of Gadarif city. Sampling sites in the northern area were Elekharesh, Um Ruwashid, Elhagar and Shemal Khat Elmaraa (North pasture area). Sampling sites in the southern area were Wadi Abuganafid, Wadi Abugrad, Elaadeed, Altakoon, south- east Elsaada and Wadi Abumatarig. The study was conducted from August to October 2017 and was terminated in October due to overgrazing and the area was bare after that.

### *Rangeland characteristics*

An iron quadrate (1×1m) was used to determine plants inventory, distribution and biomass. The quadrate was thrown four times on different sampling sites and plants in the quadrate were identified, counted, weighed and stored in paper bags. Shrubs and trees samples were collected and stored in paper bags. The plants samples were air dried in the laboratory and stored in polyethylene bags for laboratory analysis.

## Results

### *Rangeland plants inventory*

Table 1 shows rangeland plants inventory in the northern and southern areas, Butana plain, Gadarif State.

Thirty four plants were identified with 33 plants in the southern area and 17 plants in the northern one. Plants diversity was very high, especially in the southern area. Sixteen plants were found in the two areas and 17 plants were found in the southern area and were not found in the northern one. One plant (Seyal) was found in the northern area and was not found in the southern one.

The plants were in 20 families and the main families were Poaceae and Fapaceae. There were variations in plants numbers among families. There were 20 families in the southern area and the main family was Poaceae and 13 families in the northern area where the main family was Convolvulaceae. Six families were found in the southern area and were not found in the northern one.

### *Effects of month on rangeland plants inventory*

Table 2 shows effects of month on rangeland plants inventory in the northern and southern areas of the Butana plain, Gadarif State.

There were high monthly variations in plants inventory in the two areas in the Butana plain. Plants numbers were highest in September (44 plants) and least in August (13 plants). Plants inventory was also affected by sites and areas in different month. It was highest in the southern area in September and October and in the northern area in August. Plants' family numbers were also affected by month. Six families were found in the northern area and 5 families were found in the southern area in August. Twelve families were found in the northern area and 17 families were found in the southern one in September. Four families were found in the northern area and 6 families were found in the southern one in October. Families numbers were higher in the northern area than the southern one in August and October and was higher in the southern area in September.

In August 7 plants were found in the northern area and 6 plants were found in the southern one. Only one plant was found in the two areas (Hantout). In September 27 plants were found in the southern area and 17 plants were found in the northern one. Thirteen plants were found in the northern and southern areas. Four plants were found in the northern area and were not found in the southern one. Fourteen plants were found in the southern area and were not found in the northern one. In October 9 plants were found in the southern area and 6 plants were found in the northern one. Four plants were found in the two areas (Senamaka, Laout, Kitir and Eifain). Only one plant was found in the northern area and was not found in the southern one (Seyal). Five plants were found in the southern area and were not found in the northern one (Fagus, Um glageila, Sikiran, Safari and Tuffa).

### *Plants density*

Table 3 shows that plants density was highly affected by month and areas in the northern and southern areas of Butana plain, Gadarif State.

Plants density was higher in the southern area than in the northern one in all month. It was significantly (P>0.05) highest in August and least in October in the two areas. Mean area plant density was higher in the southern area, but not significantly (P>0.05). Mean month plants density varied significantly (P<0.05) among month and it was highest in August and least in October.

### *Frequency distribution*

#### *Grasses*

Table 4 shows effects of areas on grasses frequency distribution in the northern and southern areas, Butana plain. Grasses frequency distribution varied highly among areas in the southern and northern areas. All grasses frequency distributions were very high in the southern area compared

**Table 1.** Rangeland plants inventory in the northern and southern areas of the Butana plain, Gadarif State, Sudan.

| Plants type | Arabic name | Botanical name | Family | North | South |
|---|---|---|---|---|---|
| Forbs | Eifain | *Chenopodiastrum murale* | Amaranthaceae | ✓ | ✓ |
| Forbs | Lablab | *Digera alternifolia* | Convolvulaceae | ✓ | ✓ |
| Forbs | Turba | *Boerhavia erecta* | Nyctaginaceae | ✓ | ✓ |
| Forbs | Bassal elkilab | *Celosia argentea L.* | Amaranthoceae | | ✓ |
| Forbs | Dereisa | *Tribulus terrestris L.* | Zygophyllaceae | ✓ | ✓ |
| Forbs | Fakha | *Justicia palustris* | Acanthaceae | | ✓ |
| Forbs | Gubbein | *Solanium dupium fersen* | Solanaceae | ✓ | ✓ |
| Forbs | Um libaina | *Euphorbia uegytica* | Euphorbiaceae | ✓ | ✓ |
| Forbs | Raba | *Trianthema pentandra* | Aizoaceae | ✓ | ✓ |
| Forbs | Khudra | *Cenchorus fascicularis* | Tiliaceae | ✓ | ✓ |
| Forbs | Safari | *Crotalaria senegalensis* | Fabaceae or Leguminosae | | ✓ |
| Forbs | Umglagila | *Aristolachia bracteolate* | Cruciferae | | ✓ |
| Forbs | Sharaya | *Indigofera hochstetteri* | Violaceae | ✓ | ✓ |
| Forbs | Soreeb | *Sesbania Arabica* | Fabaceae or Leguminosae | | ✓ |
| Forbs | Lablab ahmar | *Digera muricate L.* | Amaranthaceae | ✓ | ✓ |
| Forbs | Tabar | *Ipomoea cordofana* | Convolvulaceae | ✓ | ✓ |
| Forbs | Sikiran | *Datura stramonium* | Solanaceae | ✓ | ✓ |
| Forbs | Tamalaika | *Acalypha indica L.* | Euphorbiaceae | | ✓ |
| Forbs | Rehan | *Ocimum basilicum* | Lamiaceae | | ✓ |
| Forbs | Fagus | *Cucmis melo* | Cucurbitaceae | | ✓ |
| Forbs | Senamaka | *Cassia senna L.* | Fabaceae or Leguminosae | ✓ | ✓ |
| Forbs | Hantot | *Ipomea sinensis* | Convolvulaceae | ✓ | ✓ |
| Forbs | Hanzal | *Colocynthis vulgaris* | *Cucurbitaceae* | | ✓ |
| Forbs | Alhirasha | *Alysicarpus monilifer* | Fabaceae or Leguminosae | | ✓ |
| Tree | Laout | *Acacia nubica* | Fabaceae or Leguminosae | ✓ | ✓ |
| Tree | Seyal | *Acacia tortilis* | Mimosaceae | ✓ | |
| Tree | Sonout | *Acacia nilotica* | Mimosaceae | | ✓ |
| Grass | Asslug | *Saponaria officinalis* | Caryophyllacea | | ✓ |
| Grass | Abolisag | *Setaria verticillata* | Poaceae | | ✓ |
| Grass | Tuffa | *Urochloa trichopus* | Poaceae | | ✓ |
| Grass | Donbolab | *Schima ischaemoides* | Poaceae | | ✓ |
| Grass | Muhutriba | *Acalypha indica* | Poaceae | | ü |
| Shrub | Kitir | *Acacia mellifera L.* | Mimosaceae | ✓ | ✓ |
| Shrub | Ghabash | *Guiera senegalensis* | Combretaceae | | ✓ |
| Total | | | | 17 | 33 |

**Table 2.** Effects of month on rangeland plants inventory in northern and southern areas of Butana plain, Gadarif State, Sudan.

| Sites / Plants | Month | | | | | |
|---|---|---|---|---|---|---|
| | August | | September | | October | |
| | North | South | North | South | North | South |
| Basal elkilab | | ✓ | | | | |
| Donbolab | | ✓ | | | | |
| Fagus | | | | ✓ | | ✓ |
| Dereisa | | | ✓ | ✓ | | |
| Gubbein | | | ✓ | ✓ | | |
| Hanzal | | | | ✓ | | |
| Sharaya | ✓ | | ✓ | ✓ | | |
| Tabar | | | ✓ | ✓ | | |
| Umglagila | | | ✓ | | | ✓ |
| Turba | | ✓ | ✓ | | | |
| Khudra | ✓ | | ✓ | ✓ | | |
| Sanamaka | ✓ | | ✓ | | ✓ | ✓ |
| Umlibaina | | | ✓ | ✓ | | |
| Sikiran | ✓ | | ✓ | ✓ | | ✓ |
| Rehan | | | | ✓ | | |
| Hantout | ✓ | ✓ | ✓ | ✓ | | |
| Laout | | | ✓ | ✓ | ✓ | ✓ |
| Kitir | ✓ | | ✓ | ✓ | ✓ | ✓ |
| Tamalaka | | | | ✓ | | |
| Eifain | | ✓ | | ✓ | ✓ | ✓ |
| Rabaa | | | ✓ | ✓ | ✓ | |
| Safari | | | | ✓ | | ✓ |
| Asslug | | ✓ | | | | |
| Seyal | ✓ | | ✓ | | ✓ | |
| Muhutriba | | | | ✓ | | |
| Sureeb | | | | ✓ | | |
| Lablab | | | ✓ | ✓ | | |
| Lablab ahamar | | | ✓ | ✓ | | |
| Sonout | | | | ✓ | | |
| Abolisag | | | | ✓ | | |
| Fakha | | | | ✓ | | |
| Ghabash | | | | ✓ | | |
| Tuffa | | | | ✓ | | ✓ |
| Alhirasha | | | | ✓ | | |
| Total | 7 | 6 | 17 | 27 | 6 | 9 |

to the northern one. Donbolab had the highest grass frequency distribution in the southern area. Five grasses were not found in the northern area (Donbolab, Aslag, Abolisag, Muhtriba and Tuffa). Plants mean frequency distribution varied among grasses. Mean grasses frequency distribution was signi ficantly ($P>0.05$) very high in the southern area.

Table 5 shows effects of month on grasses frequency distribution in the northern and southern areas, Butana plain, Gadarif State.

Grasses frequency distribution varied highly among month in all sites and in the southern and northern areas of Butana plain. Grasses frequency distribution was highest for Donbolab in August

and least for Abolisag in September. The number of absent grasses was highest in October and least in September. Mean grasses frequency distribution varied among grasses and was highest for Donbolab and least for Abolisag. Grasses frequency distribution was highest in August and was highest for Donbolab and least for Asslug. It was highest in Muhtriba and least in Abolisag in September. Plants mean frequency distribution was highest for Donbolab and least for Abolisag in October.

**Table 3.** Effects of month and area on plants density (plant/m²) in northern and southern areas in the Butana plain, Gadarif State, Sudan.

| Month | Areas | | Month mean |
|---|---|---|---|
| | Northern | Southern | |
| August | 131.00±85.00$^{b}$ | 160.25±56.12$^{c}$ | 145.63±68.49$^{a}$ |
| September | 66.25±63.39$^{b}$ | 79.25±33.08$^{b}$ | 72.75±47.32$^{b}$ |
| October | 3.00±0.00$^{b}$ | 8.75±6.65$^{a}$ | 7.06±6.31$^{c}$ |
| Area mean | 66.75±79.25$^{a}$ | 82.75±73.14$^{a}$ | 75.15±73.90 |

Means followed by similar letters were not significantly different (P>0.05) and by different letters were significantly different (P<0.05).

**Table 4.** Effects of areas on grasses frequency distribution in the northern and southern areas in Butana plain, Gadarif State, Sudan

| Plants | Areas | | Plants mean |
|---|---|---|---|
| | Northern | Southern | |
| Muhtriba | | 31.55±23.89 | 31.555±23.89 |
| Donbolab | | 31.87±31.08 | 31.87±31.08 |
| Aslag | | 11.52±3.49 | 11.515±3.49 |
| Abolisag | | 2.86±0.00 | 2.86±0.00 |
| Tuffa | | 12.26±4.54 | 12.26±4.54 |
| Area mean | | 18. 01±23.32a | 18. 01±23.32a |

Means followed by similar letters were not significantly different (p>0.05) and by different letters were significantly different (p<0.05).

**Table 5.** Effects of month on grasses frequency distribution in Butana plain, Gadarif State, Sudan.

| Plants | Month | | | Plants mean |
|---|---|---|---|---|
| | August | September | October | |
| Muhtriba | | 31.56±23.89 | | 31.56±23.89 |
| Donbolab | 31.87±31.08 | | | 31.87±31.08 |
| Asslug | 11.52±3.49 | | | 11.52±3.49 |
| Abolisag | | 2.86±0.00 | | 2.86±0.00 |
| Tuffa | | 9.54±13.40$^{b}$ | 14.97±4.54$^{a}$ | 12.26±4.54 |
| Month mean | 21.69±27.194 | 14.65±20.33 | 14.97±3.56 | 18.01±23.32 |

Means followed by similar letters were not significantly different (P>0.05) and by different letters were significantly different (P<0.05).

***Forbs***

Table 6 shows effects of areas on forbs frequency distribution in the northern and southern areas in Butana plain, Gadarif State.

Forbs' frequency distribution varied highly among sites for most plants. It was higher in the northern area than in the southern one for Khudra, Turba, Hantoat and Sharaya. It was higher in the southern area for Eifain, Sikiran and Soraib. There were no significant differences (P>0.05) in forbs frequency distribution between the two areas. In the northern area it was highest for Turba and least for Soraib. In the southern area it was highest for Gubbein and least for Soraib. Soraib had the least frequency distribution in the two areas. Forbs mean frequency distribution varied highly among plants and was highest for Turba and least for Sanamaka. Mean forbs frequency distribution was higher in the northern area than in the southern one.

**Table 6.** Effects of areas on forbs frequency distribution in the northern and southern areas, Butana plain, Gadarif State, Sudan.

| Plants | Sites | | Plants mean |
|---|---|---|---|
| | Northern | Southern | |
| Khudra | 5.99±5.70$^{a}$ | 2.91±3.62$^{a}$ | 4.23±4.48$^{a}$ |
| Turba | 80.89±16.18$^{a}$ | 5.49±0.00$^{b}$ | 70.12±32.10$^{c}$ |
| Sharaya | 22.53±20.75$^{a}$ | 6.37±3.50$^{b}$ | 15.80±17.56$^{ab}$ |
| Eifain | 33.33±0.00$^{a}$ | 43.87±27.50$^{a}$ | 42.55±25.73$^{bc}$ |
| Gubbein | | 45.16±36.16 | 45.16±36.16$^{bc}$ |
| Soraib | 2.44±0.00$^{a}$ | 2.84±2.21a | 2.71±36.16$^{a}$ |
| Dereisa | | 18.12±8.79 | 18.12±8.79$^{ab}$ |
| Um libaina | 5.50±6.024 | | 5.50±6.02$^{a}$ |
| Sanamaka | 2.48±0.00 | | 2.48±0.00$^{a}$ |
| Hantout | 54.29±0.00$^{a}$ | 5.90±1.86$^{b}$ | 15.58±21.70$^{ab}$ |
| Lablab ahmar | 2.86±0.00 | | 2.86±0.00$^{a}$ |
| Sikiran | 34.29±0.00$^{a}$ | 39.44±26.51$^{a}$ | 38.80±24.61 |
| areas mean | 33.37±34.01 | 21.47±26.34 | 26.54±30.14 |

Means followed by similar letters were not significantly different (P>0.05) and by different letters were significantly different (P<0.05).

Table 7 shows that forbs frequency distribution varied highly among month in the northern and southern areas, but this effect was only significant (P<0.05) for Gubbein, Soraib and Sikiran. Forbs frequency distribution was highest in August for khudra, Turba, Sharaya, Soraib, Sikiran and Dereisa than in September and October. It was highest for Eifain in October than in August and September. In August it was highest for Turba and least for Soraib. In September it was highest for Turba and least for

Gubbein. In October it was highest for Gubbein and least for Sikiran. Forbs frequency distribution was highest for Turba in August and September. Gubbein had the highest frequency distribution in October and the least one in September. Plants mean frequency distribution was highest for Turba and least for Sanamaka.

### *Biomass*

Table 8 shows effects of areas and month on rangeland plants biomass in the northern and southern areas, Butana plain, Gadarif State.

Mean fresh and DM biomasses varied among sites and areas and were higher in the northern area than in the southern one. However, this effect was only significant (P<0.05) for fresh matter biomass. Mean fresh and DM biomasses varied with month in the two areas, but not significantly (P>0.05). Fresh biomass was higher in the southern area in August and in the northern area in September. It was almost similar in the two areas in October. Dry matter biomass was higher in the northern area in August and in the southern area in September and October. It was not significantly affected by month (P>0.05).

## Discussion

### *Rangeland plants inventory*

High plants number and diversity indicated that the study area is a very good grazing area in Butana plain, Gadarif State. High rangeland plants diversity is very important indicating good ecosystems and improved plants palatability and nutritive value. It also has ecological and economic values (Oldeland *et al,* 2010). High plants diversity was also found in central Sudan (Braun *et al,* 1991). The high plants diversity was mainly due to good soil fertility and rainfall, especially in the southern area. The higher plants inventory in the southern area (33 plants) than the northern one (17 plants) was mainly due to relatively higher rainfall and lower grazing intensity

**Table 7.** Effects of month on forbs frequency distribution in Butana plain, Gadarif State, Sudan.

| Plants | Month | | | Plants mean |
|---|---|---|---|---|
| | August | September | OctobeOctobe | |
| Khudra | 7.20±7.50$^{a}$ | 3.04±3.15$^{a}$ | | 4.23±4.48$^{a}$ |
| Turba | 71.97±44.51$^{a}$ | 67.65±10.14$^{a}$ | | 70.12±32.10$^{c}$ |
| Sharaya | 16.53±25.90$^{a}$ | 15.28±10.84$^{a}$ | | 15.80±17.56$^{ab}$ |
| Eifain | 26.37±0.00$^{a}$ | 35.17±15.95$^{a}$ | 57.78±36.718$^{a}$ | 42.55±25.73$^{bc}$ |
| Gubbein | 12.09±0.00$^{b}$ | 1.28±0.00$^{b}$ | 70.80±10.91$^{a}$ | 45.16±36.16$^{bc}$ |
| Soraib | 4.40±0.00$^{a}$ | 1.86±0.82$^{b}$ | | 2.71±36.16$^{a}$ |
| Dereisa | 25.34±0.00$^{a}$ | 14.51±8.74$^{a}$ | | 18.12±8.79$^{ab}$ |
| Um libaina | | 5.50±6.02 | | 5.50±6.02$^{a}$ |
| Sannammaka | | 2.48±0.00 | | 2.48±0.00$^{a}$ |
| Hantoat | | 15.58±21.70 | | 15.58±21.70$^{ab}$ |
| Lablab ahmar | | 2.86±0.00 | | 2.86±0.00$^{a}$ |
| Sikiran | 54.39±24.03$^{a}$ | 25.06±16.15$^{ab}$ | 17.65±0.00$^{b}$ | 38.80±24.61 |
| Month mean | 30.21±36.54$^{b}$ | 18.00±21.72$^{b}$ | 64.29±25.26$^{a}$ | 25.68±30.14 |

Means followed by similar letters were not significantly different (P>0.05) and by different letters were significantly different (P<0.05).

**Table 8.** Effects of areas and month on rangeland plants fresh and DM biomass (tons/Fadden) in the northern and southern areas, Butana plain, Gadarif State, Sudan

| Sites/Month | Fresh | | | Dry matter | | |
|---|---|---|---|---|---|---|
| | Northern | Southern | Mean | Northern | Southern | Mean |
| August | 1.255±1.32$^{a}$ | 0.313±.24$^{a}$ | 0.784±1.02$^{a}$ | 0.384±.43$^{a}$ | 0.125±.09$^{a}$ | 0.254±.32$^{a}$ |
| September | 0.795±.37$^{a}$ | 0.515±.16$^{a}$ | 0.655±.31$^{a}$ | 0. 263±.12$^{a}$ | 0.328±.23$^{a}$ | 0.295±.17$^{a}$ |
| October | 0.280±0.00$^{a}$ | 0.285±.10$^{a}$ | 0.284±.08$^{a}$ | 0.210±00$^{a}$ | 0.231±.03$^{a}$ | 0.226±.02$^{a}$ |
| Mean | 0.942±.91$^{a}$ | 0.371±.19$^{b}$ | 0.616±.66 | 0.310±.28$^{a}$ | 0.228±.15$^{a}$ | 0.263±.22$^{a}$ |

Means followed by similar letters were not significantly different (P>0.05) and by different letters were significantly different (P<0.05).

in the southern area. Effects of rainfall (Yates *et al,* 2000, Mendez *et al,* 2011), soil (Elimam *et al,* 2025) and grazing intensity (Abdelsalam *et al,* 2017) on rangeland plants are well documented. Absence of Seyal in the southern area was mainly because trees were cut to allow cropping. Plants diversity in the study area was higher than in Abu Haraz area, Butana plain, Gezira State, Sudan (28 plants) (Elimam *et al,* 2013) and Elmanagel Plateau (EMP), Gezira State (Elimam *et al,* 2025). However, it was lower than in the Butana plain, Gezira State (35 plants) (Mohamed, 2013).

The variations in plants inventory among sites and areas in this study were also found in Butana plain, Gezira State, Sudan (Mohamed, 2013) and EMP (Elimam *et al,* 2025) and were attributed to soil types (Mohamed, 2013; Elimam *et al,* 2025) and rangeland management (Mohamed, 2013). Monthly variations in plants inventory in the two areas in this study were mainly due to variations in rainfall and grazing intensity. Similar results were reported by many authors (Mohamed, 2013; Elimam *et al,* 2025). The highest plants inventory in September was also found in the Butana plain, Gezira State and was mainly due to higher rainfall (Mohamed, 2013).

### *Rangeland plants types*

The variations in rangeland plants types between the southern and northern areas and among month in this study were mainly attributed to variations in rainfall and grazing intensity. Grazing intensity was expected to be relatively lower in the southern area which is a main cropping area. Similar variations among areas in plants types were reported by many workers (Elsadig *et al,* 2008; Mohamed, 2013; Elimam *et al,* 2025). Forbs were the main plants in the two areas indicating higher plants nutritive value and improved palatability. However, it was reported that perennial and desired plants decreased in the Sudan due to rangeland deterioration (Yagoub, 1998). The least shrubs and trees were due to their absence in the southern area due to cutting for cropping. The number of plants types was higher in August and September than October (Elimam *et al,* 2025). But, they were lower in August and October than in Butana plain, Gezira State (Mohamed, 2013).

### *Rangeland plants families*

The high number of plants families in the study area and in the southern area indicated high plants diversity which is highly desired. The higher numbers of plants families in the southern area were similar to that in Butana plain, Gezira State (Mohamed, 2013). The variations in the main families between the two areas (Poaceae in the southern area and Convolvulaceae in the northern area) reflected the variations in dominant plants between the two areas. Poaceae was also the main family in the Butana plain, Gezira State (Mohamed, 2013). Similar variations in numbers of plants families between areas were also found in Blue Nile State, Sudan (Abdelsalam *et al,* 2017). Plants family numbers in this study were higher than those in Butana plain, Gezira State (Mohamed, 2013). Forbs families also dominated in Butana plain, Gezira State. Plants family number was affected by month and areas as in Butana plain, Gezira State (Mohamed, 2013). The variations in plants family numbers among month were mainly due to variations in rainfall and grazing intensity.

### *Plants density*

The high variations in plants density among month and areas in this study were mainly due to variations in rainfall and grazing intensity. The variations among areas in plant density were also found in the Blue Nile State, Sudan (Abdelsalam *et al,* 2017). Plant density also varied between plants and years (Mohamed, 2021). The higher plant density in the southern area than in the northern one was mainly associated with higher plant inventory in the former, and was also influenced by soil and rainfall. It was also affected by grazing intensity. The highest mean plants density in August and the least in October were associated with higher rainfall in August and higher grazing intensity in October. Plant density was very high than that in the Blue Nile State (Abdelsalam *et al,* 2017), indicating better rangeland in the Butana plain, Gadarif State.

## Frequency distribution

### *Grasses*

The high variations in grasses frequency distribution between the southern and northern areas could be mainly due to the variations in rainfall and grazing intensity. Similar results were found in the Butana plain, Gezira State and were attributed to variations in rainfall, soils and grazing intensity (Mohamed, 2013; Elimam *et al,* 2025). These variations were also found between open and protected rangelands (Elhag, 2011; Abdelsalam *et al,* 2017). The higher grasses frequency distribution in the southern area was also found in the Butana plain, Gezira State and it was associated with higher rainfall and plant inventory and density in this study. Donbolab highest frequency distribution among grasses in the southern

area was the contrary to that in the Butana plain, Gezira State, where it had the least value together with Tuffa (Mohamed, 2013).

The high monthly variations in the frequency distribution between the southern and northern areas were mainly due to variations in rainfall and grazing intensity. Similar results were found in EMP (Elimam *et al,* 2025). Donbolab highest frequency distribution among grasses in August was associated with peak rainfall. Abolisag least frequency distribution among grasses in September was due to high palatability. The highest number of grasses that disappeared in October was associated with least plants inventory in the southern area and was mainly due to higher grazing intensity. The variations among grasses in mean frequency distribution and the highest value for Donbolab and the least for Abolisag could be mainly due to variations in plants palatability.

The highest monthly grasses frequency distribution in August and the least in October was mainly due to high rainfall and biodiversity in August and lower rainfall and higher grazing intensity in October. The variations among grasses in frequency distribution in August and highest values for Donbolab and least for Asslug could be mainly due to variations in plants palatability. Similar results were reported in the Butana plain, Gezira State. Muhtriba highest frequency distribution and the least value for Abolisag in September could be mainly due to variations in plants palatability and grazing intensity. Tuffa was the only grass in October could be due to low palatability. Tuffa ranked second in frequency distribution among grasses in September in the Butana plain, Gezira State and was attributed to reduced palatability (Mohamed, 2013). The variations in plants mean frequency distribution where it was highest for Donbolab and least for Abolisag could be mainly associated with plants palatability.

***Forbs***

The high variations in forbs frequency distribution between the two areas for most plants were similar to those for grasses, and were mainly due to rainfall, grazing intensity and variations in plants inventory. It was also found in EMP (Elimam *et al,* 2025) and in the Butana plain,

Gezira State (Mohamed, 2013) and were attributed to variations in rainfall, soils and grazing intensity. The variations in frequency distribution and mean frequency distribution among forbs in the southern and northern areas were mainly associated with rainfall and grazing intensity. High variations among forb in mean frequency distribution were also found by Elimam *et al* (2025) and Mohamed (2013). Sannammaka least mean frequency distribution was also found in September in the Butana plain, Gezira State and was mainly attributed to animal high preference (Mohamed, 2013).

Monthly variations in most forbs frequency distribution were mainly due to variations in rainfall and grazing intensity. Similar variations in and among sites were also found in EMP (Elimam *et al,* 2025) and Butana plain, Gezira State (Mohamed, 2013). Gubbein least frequency distribution in September and the highest one in October suggested that it was not highly preferred by animals in October. Gubbein least frequency distribution in September was also found in Butana plain, Gezira State and was attributed to limited distribution in one site (Mohamed, 2013). The higher frequency distribution in October could be mainly due to low plants preference. The variations in forbs mean frequency distribution was also found for grasses. Turba highest frequency distribution in August and September and absence in October could be due to intensive grazing in October. The variations in plants frequency distribution in August, September and October in this study and in Butana plain, Gezira State (Mohamed, 2013) were mainly due to soils and rainfall.

***Biomass***

***Fresh biomass***

The significantly higher mean biomass in the northern area than the southern one was mainly because the southern area was mainly cultivated. Areas also affected biomass in the Sudan (Elsadig *et al,* 2008; Abusuwar and Yahia, 2010; Abdelsalam *et al*, 2017, Elimam *et al,* 2025). Monthly variations in plants biomass in the two areas in this study were associated with variations in plants inventory and frequency distribution and were also affected by rainfall. It was reported that biomass was associated with rainfall (Abusuwar and Yahia, 2010) and was positively correlated with rainfall (Elsadig *et al*, 2008). It was also affected by seasons (Abusuwar and Yahia, 2010). The higher biomass in the northern area in August and September was mainly because the southern area was cultivated and the northern one is mainly a grazing site. The highest mean fresh biomass in August and least in October was associated with rainfall.

Rangeland plants biomass in Butana plain, Gadarif State was higher than that reported by many workers in the Sudan (Abusuwar and Yahia,

2010, Abdelsalam *et al*, 2017; Mohamed, 2021) and lower than in Baggara area in Kordofan and Darfur (Suleiman, 1985/87) and Elodaya protected belts (Elham, 1988). Rangeland biomass in the southern area was higher in August and September and lower in October than in Kadugli Locality, South Kordofan State, Sudan (Abdelsalam *et al*, 2016). However, in the southern area it was higher in September and lower in August and October than in Kadugli Locality.

### *Dry matter biomass*

The variations among areas in DM biomass were also found for fresh biomass in this study and were reported by many workers (Elsadig *et al,* 2008; Abusuwar and Yahia, 2010; Abdelsalam *et al*, 2017, Elimam *et al,* 2025). The least DM biomass in October in the two areas was mainly due to lower rainfall and higher grazing intensity. It was found that grazing intensity had affected DM biomass (Abdelsalam *et al,* 2017). Dry matter biomass in this study was close to that in the protected area in the Blue Nile State, Sudan (Abdelsalam *et al,* 2017) and higher than that in the White Nile State, Sudan (Saleh *et al*, 2018). The higher mean DM biomass in the northern area was associated with higher fresh biomass. Mean biomass was highly positively correlated with rainfall (Elsadig *et al,* 2008) and negatively correlated with grazing intensity (Abdelsalam *et al,* 2017). Mean monthly variations in DM biomass in the two areas in this study were also found for fresh matter and were associated with variations in rainfall and grazing intensity. August higher DM biomass in the northern area was also found for fresh biomass. The higher DM biomass in the northern area and higher fresh biomass in the southern area in September were mainly due to high DM in some plants and may be associated with plants maturity.

## References


Abdelsalam MI, Ibrahim GA, Elmagbool AH and Fashir GA. Determination of Range Plant Attributes in Kadugli Locality, South Kordofan State, Sudan. International Journal of Innovative Research in Science, Engineering and Technology. 2016; 5(2):1525- 1529. https://www.ijirset.com/upload/2016/february/69_Determination.pdf

Abdelsalam MI, Abdalla NI, Abdelkreim M, Ibrahim ME and Mohammed MM. The impact of continuous grazing on natural rangeland in Alazzazah area-Blue Nile State, Sudan. Journal of Rangeland Science. 2017; 7(40):309-314. https://www.researchgate.net/publication/320065418_The_impact_of_continuous_grazing_on_natural_rangeland_in_alazzazah_area-_Blue_Nile_State_Sudan [accessed Jun 02 2024].

Abusuwar AO, Ahmed SA and Mohamed A. Range inventory and evaluation of Zalingei area vegetation. Western Darfur State, Sudan. International Journal of Science and Nature. 2011; 2(2):248-253. https://www.researchgate.net/publication/236002580_RANGE_INVENTORY_AND_EVALUATION_OF_ZALINGEI_AREA_VEGETATION_WESTERN_DARFUR_STATE_SUDAN

Abusuwar AO and Yahia EO. Pastoralist and seasonality: their effects on range productivity and carrying capacity in a semi-arid rangeland of Sudan (Southeast Darfur State). Agricultural and Biology Journal of North America. 2010; 80-88. https://scihub.org/ABJNA/PDF/2010/2/1-2-80-88.pdf 2010; ISSN Print: 2151-7517, ISSN Online: 2151-7525© 2010,

Abusuwar AO and Darag A. The Possibility of Integration of Forage Production and Processing in Arab countries. Country Study, Sudan, AOAD. 2002; (in Arabic).

Ali MA. The performance of Desert sheep in Kordofan, Sudan. PhD Thesis, Department of Animal Production, Faculty of Agricultural Sciences. University of Gezira. Wad Medani, Sudan. 2003.

ARC. Report of the Protein Group of the ARC Working Party on the Nutrient Requirements of Ruminant Livestock. 1982; ARC, UK.

Braun M, Burgstaller H, Hamdoun AM and Walter H. Common Weeds of Central Sudan. Munster Schwazaeh. Margraf Publishers GmbH, Federal Republic of Germany. 1991.

Darosa AEM. Studies on some camel production traits and health in Butana Area, Sudan. PhD Thesis. University of Khartoum, Sudan. 2005.

Elhag AMA. Effects of rangeland protection and forage growth stage on vegetation attributes and sheep and goat selection, at north Kordofan, Sudan. Sudan Journal of Agricultural Research. 2011; 17:29-38.

Elham E. Range resources inventory for evaluation of Elodaya project for range rehabilitation, Sudan. M. Sc Thesis, Institute of Environ. Studies, University of Khartoum, Khartoum, Sudan. 1998.

Elimam ME, Mohamed A and Dafalla BFM. The nutritive value and goat preference of pasture plants in Abu Haraz area in the Butana plain, Sudan. Sudan Journal of Agricultural Research. 2013; 21:57-72.

Elimam ME, Elbahi MHO and Dafalla MA (2024). Rangeland characteristics in El Managil plateau, Gezira State, Sudan. Sinnar University Journal for Applied Sciences. 2025; (In press).

Elsadig AE, Adeeb AM, Ickowicz A, Saidi S, Eljack EA, Mustafa YM and Yousif. Impact of water harvesting techniques on rangeland characteristics of Butana area, Sudan. The 3rd International Conference on Water Resources and Arid Environments and the 1st Arab Water Forum, FAO. 2008.

Farouk DEA and Mohamed DAS. Water supply problems in the Butana region, central Sudan with special emphasis on Jebel Ali area. Geo Journal. 1982; 6(1):15-16.

Fdial MIA. Comparison of rangeland inventory techniques in semi-arid areas as related to rangeland management (Case study Kadugli Locality, Southern Kordofan

State). PhD Thesis, College of Graduate Studies, Sudan University of Science and Technology, Sudan. 2013.

Mendez RV, Ramos EV, Oleschko K, Hernandez-Sandova L and Cortazar MAD. Soil Erosion Processes in Semiarid Areas: The Importance of Native Vegetation. In Soil Erosion Studies. Chapter 2. 2011. Edited by Godone D. InTec. ISBN 978-953-307-710-9https://www.researchgate.net/publication/316881878_Soil_Erosion_Processes_in_Semiarid_Areas_The_Importance_of_Native_Vegetation.

Mohamed AM. Assessment of rangelands condition in low rainfall Savannah of Sudan. GSC Advanced Research and Reviews. 2021; 7(03):109-114, https://doi.org/10.30574/gscarr.2021.7.3.0132.

Mohammed SAA. Range plants inventory, frequency distribution and proximate analysis of rangeland plants in Um Elqura and East of Gezira Localities, Gezira State, Sudan. PhD Thesis, Department of Animal Production, Faculty of Animal Production, University of Gezira, Wad Medani, Sudan. 2013.

Mohamed AAMA, Elnour IA and Elhag FMA. Rangelands vegetation under different management systems and growth stages in North Darfur State, Sudan (Range attributes). International Journal of Environment. 2014; 3(3):332-343. https://www.researchgate.net/publication/287437755_Rangelands_Vegetation_under_Different_Management_Systems_and_Growth_Stages_in_North_Darfur_State_Sudan_Range_Attributes

Mohamed AH. Evaluation of some range plant for goats in Rahad area, Butana Plain, Sudan. M. Sc Thesis, Department of Animal Production, Faculty of Agricultural Sciences, University of Gezira, Sudan. 2001.

Oldeland J, Dreber N and Wesuls D. Diversity measures in comparative rangeland studies: application and advantages of species abundance distributions and diversity profiles. DINTERIA 2009/2010; 31:50-66. https://files01.core.ac.uk/download/16515867.pdf

Salieh EM, Abdesalam MI, Abdalla NI, Fashir GA and Abdelkreim M. Trend of change in herbaceous cover in low rainfall rangeland (Tendalti area, White Nile State - Sudan). University of Bakht Alruda. Refereed Quarterly Scientific Journal. 2018; 23:65-71. http://mag.uofb.edu.sd https://www.researchgate.net/publication/326919283

Suleiman MM. Baseline survey for Kordofan and Darfur. 1985/1987. Range and Pasture Administration Studies, Khartoum, Sudan.

Yagoub AM. Environmental consideration. Yearbook. Khartoum, Sudan. 1998; 29.

Yates CJ, Norton DA and Hobbs RJ. Grazing effects on plant cover, soil and microclimate in fragmented woodlands in south-western Australia: implications for restoration. Austral Ecology. 2000; 25(1):36-47.

DOI : 10.5958/2277-8934.2026.00010.2 *Vol 33 No 1, p 77-83*

# MY JOURNEY TO CAMEL SCIENCE: A PHARMACOLOGIST AND DRUG DISCOVERY SPECIALIST FOR THE CAMEL HEALTH

**Mahmoud Kandeel[1,2]**

[1]Department of Biomedical Sciences, College of Veterinary Medicine, King Faisal University, 31982 Al-Ahsa, Saudi Arabia
[2]Department of Pharmacology, Faculty of Veterinary Medicine, Kafrelsheikh University, 33516 Kafrelsheikh, Egypt

## ABSTRACT

This article presents my personal and scientific perspective as a pharmacologist and drug discovery specialist for camel research. My main aim over the last ten years was to provide a multidisciplinary contributions for the advancement of camel health through pharmacology, molecular modelling, bioinformatics, and veterinary medicine. Between 2014 and 2024, this research resulted in 54 publications across 26 journals with a strong international collaboration network involving 99 coauthors. The main areas of research were drug discovery for Middle East Respiratory Syndrome Coronavirus (MERS-CoV), pharmacokinetics of veterinary drugs in camels, bibliometric research on camel science around the globe, meta-analyses for the therapeutic applications of camel milk, camels as hosts for zoonotic diseases, trypanosomiasis as a neglected disease in camels, identification of antiparasitic molecules, molecular modeling of pathogen–host interactions including the understanding of camel-specific metabolic pathways. The use of a One Health strategy through these multidisciplinary contributions resulted in the discovery of new therapeutic options for camel diseases. The research also led to 15 patents in drug discovery, including United States patents targeting MERS-CoV fusion inhibition and broad-spectrum antitrypanosomal compounds relevant to camel health. These interdisciplinary studies combined with my experimental pharmacology findings represent an integrated effort in computational drug discovery, in vitro investigative pharmacology, and One Health approach applied to camel diseases that deserves a new therapeutic option. Personally, I am grateful for the opportunities I was blessed with through this journey and I look forward to further efforts and discoveries that will contribute effectively to camel health and welfare.

**Key words:** Bibliometric analysis, camel milk, camel research, drug discovery, mers-cov, molecular modeling, one health, pharmacokinetics, trypanosomiasis, veterinary pharmacology

### When Camels Know You Care: A Heartfelt Bond with Camels and a Mission to Heal

Fig 1 vividly reflects my deep affection for camels and the strong social bond I share with them. Over the years, I have developed not only a scientific interest in camels but also a personal connection that goes beyond research. Every visit to camel farms brings moments of genuine warmth—camels approaching me with affection, recognising my presence, and initiating physical contact. This behaviour strengthens my belief in a unique hypothesis: that camels can sense human emotions and remember individuals who treat them with kindness. In other words, camels can recognise that I love them, and I want to treat their diseases. Their response to my visits is always joyful, further confirming the emotional intelligence of these miraculous animals.

Beyond this emotional connection, my professional commitment lies in treating camel diseases and exploring innovative drug therapies to improve their health. I am dedicated to advancing research that leads to the development of effective, camel-specific medications. My presence in the field with camels represents more than routine work—it is a convergence of passion, compassion, and scientific purpose aimed at serving the well-being of camels through discovery and care.

### Publications and its metrics

Between 2014 and 2024, my scientific journey in camel research has been marked by the publication of 54 documents across 26 sources, reflecting a consistent annual growth rate of 23.11% (Fig 2). This body of work, shaped through collaboration with 99 co-authors and a high international co-authorship rate of 90.74%, underscores the global relevance and cooperative spirit of this research. With an average of 4.56 co-authors per publication and over 1,900 references cited, my work demonstrates both depth

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

and breadth in scholarly engagement. The average document age of 4.3 years, highlighting the sustained influence and evolving nature of my contributions to camel health and pharmacological sciences.

**My research keywords**

The word cloud illustrates the central themes and research interests that have shaped my scholarly contributions over the past decade, with "camel" emerging as the dominant keyword, reflecting a strong focus on camel health and biology (Fig 2). Other prominent terms such as "molecular modeling," "pharmacokinetics," "molecular dynamics," and "drug discovery" highlight the integration of computational and pharmacological approaches in my work. Key disease-related terms like "coronavirus," "MERS-CoV," "SARS-CoV-2," and "*Trypanosoma evansi*" underscore my engagement with infectious diseases of zoonotic and veterinary importance. Additionally, the presence of keywords such as "meta-analysis," "bioinformatics," "pharmacokinetics," "molecular dynamics," and "vaccines" emphasises the methodological diversity, while topics like "camel milk," "docking," and "cephalosporins" reflect my exploration of therapeutics and natural products within the context of camel medicine and one health.

**The citation metrics**

The publications received a total of 1,033 citations. The highest-cited paper has 295 citations, and the second-highest has 148. Five papers have over 50 citations, while 11 papers have 20 or more. In contrast, 14 papers have fewer than 3 citations, and 5 papers have zero citations, mostly from 2024. The mean citation count per paper is approximately 19.1, while the median is 5. Such high citation count in some papers is attributed to the impact of the recently emerged viral infections.

**Research themes and clusters**

My research can be divided into five clusters (Fig 2). Cluster 1 includes high-impact topics related to viral infections, such as COVID-19, SARS-CoV-2, MERS-CoV, coronavirus, bioinformatics, and molecular dynamics, all of which are associated with high citation rates and significant scholarly attention, especially during and after the pandemic period. Cluster 2 centres around camel-related research, encompassing terms like camel, cephalosporins, and pharmacokinetics. Cluster 3 brings together keywords such as camel milk, meta-analysis, vaccine, and MERS-CoV. Cluster 4 contains drug discovery-oriented terms and efforts against camel parasites such as drug discovery, pyrimidine, and *Trypanosoma evansi*. Lastly, Cluster 5 features molecular and enzymatic research themes with keywords like cytochrome P450, docking, and molecular modeling.

**The annual scientific production**

The annual scientific production ranged from 1-4 annual articles from 2014 to 2019, followed by a sharp rise in 2020 with 14 published articles. From 2021 to 2024, the output remained significant, contributing consistently to a total of 54 publications over the period (Table 1).

**The sources of publications**

The publications were distributed across 26 journals, with the Journal of Camel Practice and Research leading with 12 articles, followed by Frontiers in Veterinary Science with 6 articles. Other notable sources include Biological and Pharmaceutical Bulletin, Journal of Medical Virology, Open Veterinary Journal, Tropical Animal Research and Production, Biomolecules and Therapeutics, and Computational Biology and Chemistry (Table 1).

**Top coauthors**

While 99 coauthors were identified the most frequent co-authors are Al-Taher A (20), Al-Nazawi M (11), Marzok M (7), Albokhadaim I (5), Fayez M (5), and Venugopala KN (5). Other notable co-authors include Al Khodair KM, Alhojaily S, Kitade Y, Kwon H-J, Morsy MA, and Park BK, each with 4 publications (Table 1).

**Patents**

I was granted 15 patents in drug discovery. Two United States patents are highly relevant to camel health and disease control. The first, US10975126B1, titled "*MERS-CoV Inhibitor Peptides*", involves the development of peptide-based inhibitors targeting the Middle East Respiratory Syndrome Coronavirus (MERS-CoV), a zoonotic virus for which camels are known reservoirs. The second, US11801249B1, titled "*Broad-spectrum antitrypanosomal compounds*", addresses the treatment of trypanosomiasis, a parasitic disease significantly affecting camels, by introducing novel compounds with broad-spectrum efficacy against Trypanosoma species. Both inventions contribute critically to the advancement of camel-related biomedical research and veterinary therapeutics (Fig 3). The full details of publications and patents can be accessed through my Scopus author search (https://www.scopus.com/authid/detail.uri?authorId=22937486100).

**MERS-CoV**

Preliminary data from our earlier studies highlight the potential of targeting the viral fusion process as an effective strategy against MERS-CoV. Through this approach, we have identified several first-generation inhibitors that exhibit promising antiviral activity (Kandeel 2023; Kandeel *et al,* 2020a; Kandeel *et al,* 2020b; Kandeel *et al,* 2021c). In 2017, we used molecular dynamics simulations to study the structural flexibility of MERS-CoV NSP3 and its interaction with ubiquitin, revealing unique conformational changes and immune evasion mechanisms. The findings emphasise the distinct flexibility of MERS-CoV papain-like protease (Plpro) compared to SARS-CoV, offering insights crucial for designing effective antiviral inhibitors (Alfuwaires *et al,* 2017). In 2020, we explored the antiviral activities of various dendrimers against MERS-CoV (Kandeel *et al,* 2020a). Our evaluation of dendrimers showed that polyanionic types significantly reduced MERS-CoV plaque formation without cytotoxic effects, highlighting their potential as promising antiviral agents.

Further, in 2020, we identified new small-molecule fusion inhibitors targeting the MERS-CoV spike (S) protein through structure-based virtual screening (Kandeel *et al,* 2020b). Screening 1.56 million compounds led to the identification of three potent inhibitors (compounds 22, 73, and 74) that effectively reduced MERS-CoV plaque formation by targeting the fusion process and no observed cytotoxicity in HEK293 and Vero cells.

In 2021, our group conducted a comprehensive study to develop potent peptides aimed at inhibiting MERS-CoV fusion (Kandeel *et al,* 2021c). The study designed eleven mutated peptides targeting the HR1 domain of the MERS-CoV spike protein, several of which showed nanomolar $IC_{50}$ values and over 95%

**Table 1.** The statistics of scientific production.

| **Annual Scientific Production** | | **Sources of publications** | |
|---|---|---|---|
| **Year** | **Articles** | **Journal** | **Articles** |
| 2014 | 1 | JOURNAL OF CAMEL PRACTICE AND RESEARCH | 12 |
| 2015 | 1 | FRONTIERS IN VETERINARY SCIENCE | 6 |
| 2016 | 2 | BIOLOGICAL AND PHARMACEUTICAL BULLETIN | 3 |
| 2017 | 4 | JOURNAL OF MEDICAL VIROLOGY | 3 |
| 2018 | 1 | OPEN VETERINARY JOURNAL | 3 |
| 2019 | 2 | TROPICAL ANIMAL HEALTH AND PRODUCTION | 3 |
| 2020 | 14 | BIOMOLECULES AND THERAPEUTICS | 2 |
| 2021 | 8 | COMPUTATIONAL BIOLOGY AND CHEMISTRY | 2 |
| 2022 | 6 | PAKISTAN VETERINARY JOURNAL | 2 |
| 2023 | 7 | VETERINARY WORLD | 2 |
| 2024 | 8 | ACTA VETERINARIA HUNGARICA | 1 |
| Total | 54 | ACTA VIROLOGICA | 1 |
| **Top coauthors** | | ANIMALS | 1 |
| **Coauthor** | **Articles** | EXPERT OPINION ON DRUG DISCOVERY | 1 |
| AL-TAHER A | 20 | FRONTIERS IN PHARMACOLOGY | 1 |
| AL-NAZAWI M | 11 | INTERNATIONAL IMMUNOPHARMACOLOGY | 1 |
| MARZOK M | 7 | INTERNATIONAL JOURNAL OF PHARMACOLOGY | 1 |
| ALBOKHADAIM I | 5 | JOURNAL OF ANIMAL AND PLANT SCIENCES | 1 |
| FAYEZ M | 5 | JOURNAL OF BIOMOLECULAR STRUCTURE AND DYNAMICS | 1 |
| VENUGOPALA KN | 5 | JOURNAL OF VIROLOGICAL METHODS | 1 |
| AL KHODAIR KM | 4 | LETTERS IN DRUG DESIGN AND DISCOVERY | 1 |
| ALHOJAILY S | 4 | LIFE SCIENCES | 1 |
| KITADE Y | 4 | ONE HEALTH | 1 |
| KWON H-J | 4 | PEERJ | 1 |
| MORSY MA | 4 | SLOVENIAN VETERINARY RESEARCH | 1 |
| PARK BK | 4 | TROPICAL BIOMEDICINE | 1 |

**Fig 1.** In the company of camels: love, research, and discovery.

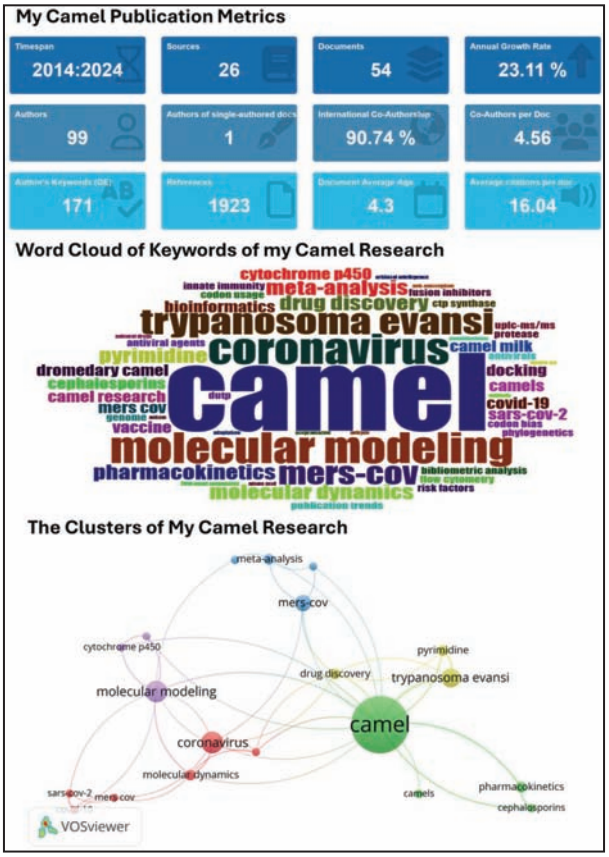



**Fig 2.** Summary of my camel research.

inhibition of plaque formation at 10 μM without cytotoxicity, effectively blocking viral fusion and entry.

Kandeel *et al* (2022) conducted a meta-analysis to determine the prevalence and seroprevalence of MERS-CoV in camels and humans across sub-Saharan Africa and the Middle East (Kandeel, 2022). This meta-analysis of 13 studies revealed a moderate MERS-CoV prevalence (38.14%) and high seroprevalence (80.66%) in camels, with limited zoonotic transmission to humans, highlighting the need for further research to better understand and control MERS-CoV transmission dynamics. Finally, an important review was published in Expert Opinion on Drug Discovery discussed the major developments and gaps in the discovery of drugs against MERS-CoVs (Kandeel 2023).

## Pharmacokinetics

Over the past years, I have conducted research on the pharmacokinetics of drugs in camels, addressing a critical knowledge gap in veterinary pharmacology. My work has included in-depth studies on various antibiotics and sedatives, such as cefquinome, cefotaxime, acepromazine, and ceftiofur. These studies revealed distinctive pharmacokinetic features in camels, including rapid drug distribution, prolonged elimination half-lives, and noticeable tissue distribution compared to other species. Such findings underscore the necessity of camel-specific dosing regimens to ensure efficacy and safety (Altayban *et al,* 2020a; Altayban *et al,* 2020b; Kandeel *et al,* 2021a; Kandeel *et al,* 2021b).

## Bibliometric studies

My efforts in the field of bibliometric studies of camel research have led to several analyses exploring regional and global trends in camel-related research. I conducted bibliometric studies across North America, South Asia, North Africa and China, utilising tools like VOSviewer and Bibliometrix to examine publication patterns, collaborative networks, thematic evolution, and disciplinary intersections. These analyses highlighted a growing global interest in camel research beyond traditional regions, with North America showing strong international collaborations, South Asia focusing on camel milk's therapeutic properties and molecular biology, and North Africa emphasising physiology, reproduction, and disease control. In addition, China enriched camel research with unique genomics and food analysis


**Fig 3.** The MERS-CoV spike and the Trypanosoma`s nucleic acids metabolising enzymes were the main focus of investigations, publications and patents.

studies (Alsaleem and Kandeel, 2024; Kandeel, 2024a; Kandeel *et al,* 2023; Kandeel, 2024b; Naji *et al,* 2024).

### Meta-analysis

My efforts in the field of meta-analysis of camel-related topics have focused on systematically evaluating the therapeutic and zoonotic implications of camel milk and MERS-CoV infections. I conducted several reviews and meta-analyses to assess camel milk's efficacy in treating diabetes and autism symptoms, as well as the prevalence and seroprevalence of MERS-CoV in camels and humans. The results demonstrated that camel milk significantly improves HbA1c% in diabetic patients and shows potential in alleviating autism symptoms, though with varying statistical significance. Additionally, the results highlighted the high prevalence of MERS-CoV in camels but noted limited zoonotic transmission to humans (Alkattan *et al,* 2023; Kandeel *et al,* 2024).

### Antiparasitic agents in camels

I have focused extensively on the treatment of camel parasites, particularly trypanosomiasis and camel nasal bots. My research includes the discovery of novel antitrypanosomal compounds with broad-spectrum activity (USA patent). Additionally, I have compared the efficacy of various available drugs to optimise therapeutic strategies (Aljasim *et al,* 2024).

### Neglected camel diseases

My research has shed light on the overlooked burden of neglected camel diseases, which often lack adequate diagnostic tools, treatments, and surveillance despite their economic and zoonotic impacts. By investigating pathogens like *Trypanosoma evansi*, the research uncovered critical metabolic pathways that could serve as drug targets, while the work on Rift Valley fever virus (RVFV) and bovine viral diarrhea virus (BVDV) highlighted understudied transmission risks in camel populations. Despite the high prevalence of these diseases, limited funding and research focus persist, leaving gaps in vaccine development and control strategies.

### Immunology and vaccine response

Through systematic reviews, we evaluated the efficacy of various vaccine platforms, including MVA-based vaccines, ChAdOx1, and DNA vaccines (GLS-5300), in eliciting robust immune responses. These vaccines induce strong antibody and cellular immunity, though durability and cross-protection remain challenges. Additionally, we explored the immunomodulatory effects of camel milk, revealing its potential to enhance anti-inflammatory and antioxidant biomarkers, which could complement vaccine strategies. By integrating bioinformatics and molecular dynamics, we also identified critical epitopes in viral proteins, such as the MERS-CoV spike or N protein, guiding the design of next-generation vaccines with improved specificity and efficacy. Beyond MERS-CoV, our studies on camel leukocyte responses and host-pathogen interactions provided foundational insights into innate and adaptive immunity in dromedaries. For instance, our investigation into cyclooxygenase inhibitors (e.g., lornoxicam) revealed their role in modulating leukocyte function, requiring attention for immunosuppression.

### Molecular modelling

Molecular modeling has been instrumental in deciphering the structural and functional dynamics of key microbial and host proteins, particularly in the context of MERS-CoV, Trypanosoma specific and camel-specific metabolic pathways. Using computational techniques such as molecular dynamics simulations, docking studies, and comparative genomics, critical mechanisms of viral entry, drug resistance, host adaptation and specific metabolic differences were uncovered. For instance, studies on MERS-CoV fusion proteins, papain-like protease, and helicase revealed conserved binding sites and allosteric pockets, enabling the rational design of small-molecule inhibitors and peptide-based antivirals. Additionally, modeling of camel

cytochrome P450 enzymes, haemoglobin, insulin, insulin receptor and host and parasite nucleotides metabolising enzymes provided insights into species-specific drug metabolism and enzyme functions (Al-Hizab and Kandeel 2022; Kandeel *et al,* 2022; Kandeel and Suganuma 2024).

**Ethics approval and consent to participate**

Not applicable

**Consent for publication**

Not applicable

**Availability of data and materials**

Available

**Competing interests**

There is no conflict of interests

**Funding**

No specific funding.

**Acknowledgement**

I sincerely thank Dr. Tarun Kumar Gahlot, Editor of the Journal of Camel Practice and Research, for conceptualising "My Journey to Camel Science" and graciously inviting me to share my personal experiences and reflections from my scientific journey in the field of camel research.

## References

Al-Hizab FA and Kandeel M. The camels, humans and bovines haemoglobin: In silico and molecular dynamics perspective and binding potency with haeme. Journal of Camel Practice and Research. 2022; 29:305-311. https://doi.org/10.5958/2277-8934. 2022.00042.X

Alfuwaires M, Altaher A and Kandeel M. Molecular dynamic studies of interferon and innate immunity resistance in MERS CoV non-structural protein 3. Biological and Pharmaceutical Bulletin. 2017; 40:345-351. https://doi.org/10.1248/bpb.b16-00870

Aljasim Y, Aljazzar A, Al-Sabi M, Alhojaily S, Albokhadaim I and Kandeel M. Comparative larvicidal potency of ivermectin, doramectin, moxidectin, and eprinomectin against dromedary camel nasal bots (*Cephalopina titillator*). Journal of Camel Practice and Research. 2024; 31:285-289. https://doi.org/10.5958/2277-8934.2024.00054.5

Alkattan A, Alkattan A, Afzal S, Manap ASA and Kandeel M. Camel milk and it's applications in treatment of diabetes: systematic review and meta-analysis. Journal of Camel Practice and Research. 2023; 30:257-265. https://doi.org/10.5958/2277-8934.2023.00033.4

Alsaleem A and Kandeel M. The Trends Of Camel Research In North America: A Bibliometric Approach. Journal of Camel Practice and Research. 2024; 31:131-145. https://doi.org/10.5958/2231-6736.2024.00027.X

Altayban A, Kandeel M, Kitade Y and Al-Nazawi M. A pilot study on the pharmacokinetics of a single intramuscular injection of cefquinome in Arabian camel calves. Acta Veterinaria Hungarica. 2020a; 68:59-64. https://doi.org/10.1556/004.2020.00008

Altayban A, Kandeel M, Tahoun A and Al-Nazawi M. Cefotaxime pharmacokinetics in Arabian camel (*Camelus dromedarius*) calves after single intravenous injection. Tropical Animal Health and Production. 2020b; 52:887-891. https://doi.org/10.1007/s11250-019-02080-0

Kandeel M. Meta-analysis of seroprevalence and zoonotic infections of Middle East respiratory syndrome coronavirus (MERS-CoV): A one-health perspective. One Health. 2022; 15:100436. https://doi.org/10.1016/j.onehlt.2022.100436

Kandeel M. An overview of the recent progress in Middle East Respiratory Syndrome Coronavirus (MERS-CoV) drug discovery. Expert Opinon on Drug Discovery. 2023; 18:385-400. https://doi.org/10.1080/17460441.2023.2192921

Kandeel M. Trends in camel research in south Asia: A bibliometric approach. Veterinary World. 2024a; 17:2763-2773. https://doi.org/10.14202/vetworld.2024.2763-2773

Kandeel M, Al-Taher A, Park BK, Kwon HJ and Al-Nazawi M. A pilot study of the antiviral activity of anionic and cationic polyamidoamine dendrimers against the Middle East respiratory syndrome coronavirus. Journal of Medical Virology. 2020a; 92:1665-1670. https://doi.org/10.1002/jmv.25928

Kandeel M, Almubarak AI, Hussen J, El-Deeb W and Venugopala KN. Pharmacokinetic, clinical, and myeloid marker responses to acepromazine sedation in Arabian camels. Frontiers in Veterinary Science. 2021a; 8. https://doi.org/10.3389/fvets.2021.725841

Kandeel M, El-Deeb W, Fayez M and Ghoneim I. Pharmacokinetics of the long-acting ceftiofur crystalline-free acid in Arabian she-camels (*Camelus dromedarius*). Slovenian Veterinary Research. 2021b; 58:95-101. https://doi.org/10.26873/SVR-1074-2020

Kandeel M, El Sebaei MG, Ba Abdullah MM, Al-Sultan SI and Abdel-Raheem SM. Bioinformatics and molecular modeling of the camel insulin receptor. Journal of Camel Practice and Research. 2022; 29:7-15.

Kandeel M, Morsy MA, Abd El-Lateef HM, Marzok M, El-Beltagi HS, Al Khodair KM, Soliman WE, Albokhadaim I and Venugopala KN. A century of "Camel Research": a bibliometric analysis. Frontiers in Veterinary Science. 2023; 10. https://doi.org/10.3389/fvets.2023.1157667

Kandeel M, Morsy MA, Al Khodair KM and Alhojaily S. Meta-analysis of the efficacy of camel milk consumption for improving autism symptoms in children in randomised clinical trials. Open Veterinary Journal. 2024; 14:2441-2452. https://doi.org/10.5455/OVJ.2024.v14.i9.33

Kandeel M and Suganuma K. Broad-spectrum trypanocidal activity of the natural citrus flavanone glycosides hesperidin and neohesperidin dihydrochalcone. International Journal of Pharmacology. 2024; 20:785-793.

Kandeel M, Yamamoto M, Al-Taher A, Watanabe A, Oh-Hashi K, Park BK, Kwon HJ, Inoue JI and Al-Nazawi M. Small molecule inhibitors of middle east respiratory syndrome coronavirus fusion by targeting cavities on heptad repeat trimers. Biomolecules and Therapeutics. 2020b; 28:311-319. https://doi.org/10.4062/biomolther.2019.202

Kandeel M, Yamamoto M, Park BK, Al-Taher A, Watanabe A, Gohda J, Kawaguchi Y, Oh-Hashi K, Kwon HJ and Inoue JI. Discovery of new potent anti-mers cov fusion inhibitors. Frontiers in Pharmacology. 2021c; 12:685161. https://doi.org/10.3389/fphar.2021.685161

Kandeel M. Bibliometric analysis of camel research in china: research trends and thematic evolution. Egyptian Journal of Veterinary Sciences. 2024b:1-16.

Naji R, Kandeel M and Mahmoud M. A bibliometric analysis of six decades of camel research in North Africa: Trends, collaboration, and emerging themes. Open Veterinary Journal. 2024; 14:3505-3524. https://doi.org/10.5455/OVJ.2024.v14.i12.34

## 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<br>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 : 01.04.2026

Sd/-
Signature of Publisher

# BACK ISSUES OF JCPR AVAILABLE

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

JOURNAL OF CAMEL PRACTICE AND RESEARCH

www.camelsandcamelids.com • www.indianjournals.com

Volume 28 December 2021 Number 3

MABROKAN BORN AGAIN BY SOMATIC CELL NUCLEAR TRANSFER

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

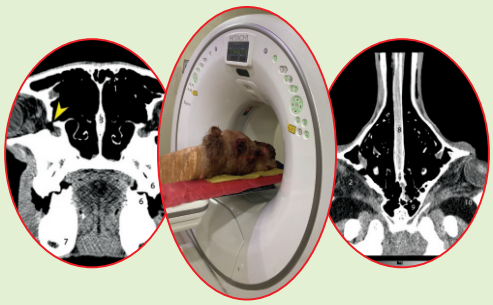
JOURNAL OF CAMEL PRACTICE AND RESEARCH

www.camelsandcamelids.com • www.indianjournals.com

Volume 29 April 2022 Number 1

## In This Issue





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

JOURNAL OF CAMEL PRACTICE AND RESEARCH

www.camelsandcamelids.com • www.indianjournals.com

Volume 29 August 2022 Number 2

## In This Issue



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

JOURNAL OF CAMEL PRACTICE AND RESEARCH

www.camelsandcamelids.com • www.indianjournals.com

Volume 29 December 2022 Number 3

JCPR COMPLETES JOURNEY OF 29 YEARS

See the details of list of contents of all previous issues of JCPR on our website
www.camelsandcamelids.com

Kindly refer querries to: Dr. T.K. GAHLOT, Editor, JCPR
email: tkcamelvet@yahoo.com

DOI : 10.5958/2277-8934.2026.00011.9 Vol 33 No 1, p 85-91

# MY JOURNEY TO CAMEL SCIENCE: A LIFELONG ADVENTURE INTO THE WORLD OF DESERT GIANTS

**Binoy Sebastian Vettical**

Editorial Board Member, Journal of Camel Practice and Research; Senior Scientist, Reproductive Biotechnology Centre, Central Veterinary Research Laboratory, Dubai, United Arab Emirates; Former Deputy General Manager, Kerala Livestock Development Board, Kerala, India

## ABSTRACT

This narrative outlines the professional journey of Dr. Binoy Sebastian Vettical from foundational education in veterinary science in Kerala, India, to a senior scientific role in camel reproductive biotechnology in the United Arab Emirates. Beginning with foundational work in bovine embryo transfer at the Kerala Livestock Development Board (KLDB), he contributed to the establishment of integrated embryo transfer laboratories, optimisation of super ovulation and embryo recovery protocols, and the production of India's first ethylene glycol direct frozen embryo-transfer calf. His academic advancement, including a Master's degree in Animal Reproduction, Gynaecology, and Obstetrics, together with specialised international training in embryo transfer, *in vitro* fertilisation (IVF), Ultra sound guided ovum pick up (OPU) and sex-sorted semen technology, strengthened his technical and research expertise. In 2010, he transitioned to camel reproductive programs in the UAE, where, at the Abu Dhabi Food Control Authority and later at the Central Veterinary Research Laboratory, Dubai, he established and directed Multiple Ovulation and Embryo Transfer (MOET) initiatives in dromedary camels, achieving average embryo recovery rates of six viable embryos per super ovulation and approximately 60% embryo transfer success. While camel embryo transfer and somatic cell nuclear transfer (SCNT) were already being practiced in a limited number of specialised centres, his role focused on strengthening, systematising, and supporting SCNT-related embryo production and transfer programs within structured laboratory and field frameworks. Beyond technical contributions, his work encompasses institutional development, laboratory accreditation, formulation of minimum standard protocols, and capacity building through national and international training, reflecting a career dedicated to advancing applied reproductive biotechnology for genetic improvement and conservation in desert-adapted species.

**Key words:** Camel, cattle, dromedary, embryo transfer, MOET, reproductive biotechnology, SCNT

Growing up in a small village in the southern state of Kerala, India, my childhood was filled with simple joys—playing with a cat and a dog, speaking to them, and sometimes sharing a quiet nap with my cat curled up beside me. Although I harbored a deep love for animals, I never imagined that one day I would find myself at the forefront of scientific research involving the majestic camel, a creature I had never encountered in my early years beyond the confines of a zoo.

My academic interests as a child were far removed from the world of animals. I was captivated by the abstract beauty of mathematics and physics, disciplines that seemed to offer endless possibilities. Yet, life has a way of leading us down unexpected paths, and my early love for animals gradually shifted toward veterinary science.

## The Beginning of My Professional Journey

In December 1984, I joined Kerala Agricultural University, Trichur, India, to pursue a Bachelor of Veterinary Science and Animal Husbandry (B.V.Sc & AH). It was here that the seeds of my professional journey were first planted. The academic foundation I received during those formative years ignited my passion for veterinary science and animal reproduction.

In 1991, I began my professional career as an Assistant Manager at the Kerala Livestock Development Board (KLDB), Mattupatti, Kerala, India, the former Indo-Swiss Project. This marked the true beginning of my exploration into advanced reproductive technologies in livestock.

The KLDB played a major role in strengthening and modernising cattle breeding activities in the state

SEND REPRINT REQUEST TO BINOY SEBASTIAN VETTICAL email: drbinoyvs@gmail.com

of Kerala while also extending technical support to other states.

**Pioneering Contributions in Embryo Transfer and Advanced Reproductive Technologies**

Recognising the immense potential of emerging reproductive biotechnologies, KLDB took on the challenge of introducing and developing embryo transfer technology to further accelerate genetic improvement in cattle. During this crucial phase of technological transition, I was unexpectedly selected to be part of the initial development team. This opportunity came at a formative stage in my career and proved to be a defining turning point.

Over the years, I had the privilege of undergoing specialised training programs both in India and abroad, which significantly broadened my expertise. Notably, I received advanced training in embryo transfer technology at Swiss Embryo Transfer (SET), Switzerland; the Institute for Animal Breeding and Genetics, University of Veterinary Medicine, Germany; and Holland Genetics, The Netherlands. During my training period in Switzerland, I achieved a 51% embryo transfer success rate in Holstein Friesian (HF), Jersey, Brown Swiss, and Simmental breeds in 1993-94.

Equipped with this global exposure and technical knowledge, I played a key role in establishing a full-fledged laboratory for cattle embryo transfer housing embryo production, cryopreservation, embryo transfer, training, research, and consultancy at the Mattupatti unit under the KLDB in 1995 (Fig 1). This integrated facility enabled the successful implementation of advanced embryo transfer programs and led to the production of India's first ethylene glycol direct frozen embryo transfer calf on 23 June 1996, marking a significant milestone in bovine reproductive biotechnology in the country (Fig 2). This achievement represented a turning point in my career, allowing me to contribute directly to the advancement of reproductive biotechnology in the region (Vettical *et al*, 2002a, 2002b, 2002c, 2002d). Conducted systematic trials and standardised procedures in cattle embryo transfer under tropical conditions, optimising applications to enhance and continuously support existing breeding programs in a cost-effective manner in the region.

In 2002, I had the opportunity to undergo hands-on training in "Sex-Sorted Semen Production Technology" at Big X AG, Switzerland. Working closely with their expert team provided me with valuable insights into the significance and transformative potential of this advanced technology in accelerating genetic progress and enhancing cattle productivity (Vettical and Das, 2007).

In addition to my primary areas of specialisation, I actively pursued further training in advanced reproductive techniques. I underwent specialised training in "*In vitro* Fertilisation of Farm Animal Oocytes" at Madras Veterinary College, Tamil Nadu, India. I also completed an advanced course in intra cytoplasmic sperm injection (ICSI) at the Centre for Reproductive Medicine (CRM, USA) – EART, Mumbai.

**Academic Excellence, Research, and Professional Knowledge Dissemination**

My MVSC thesis focused on *in vitro* fertilisation (IVF) of bovine oocytes, which further deepened my expertise in assisted reproductive technologies. The findings from this research led to the publication of three scientific papers in international journals (Vettical, 2016a, 2016b, 2016c). This research built upon my early career work in further possible advancements incorporating *in vitro* embryo production strategies and strengthened my research potential and commitment to advancing veterinary reproductive science.

**Transition to Camel Reproductive Biotechnology**

Although my early work revolved around bovines, I had yet to encounter the world of camels. It wasn't until later, when I began my professional career, that the true adventure began.

By 2005, I had already established myself as a leader in the biotechnology field, working with KLDB. It was here that I began managing projects in embryo transfer and reproductive technology. Little did I know that this experience would lay the foundation for a future I could never have predicted one that would bring me face to face with the enigmatic and resilient dromedary camel.

In 2010, my career took an unexpected turn when I moved to the United Arab Emirates (UAE) to work as an Embryo Transfer Specialist with the Abu Dhabi Food Control Authority in response to a unique professional opportunity that had arisen. It was here that I first began working with camels, assisting and taking technical leadership in the creation of a laboratory for camel embryo transfer. My work in this new field ranging from hormonal treatments for superovulation to the transfer of embryos soon gained attention for its success (Fig 3,4). Within just a couple of years, I helped the facility achieve a remarkable

60% success rate in embryo transfer in camels, a feat that opened the door to more advanced research and opportunities.

I joined Abu Dhabi Food Control Authority (ADFCA), Abu Dhabi, UAE as Embryo Transfer Specialist / Department Head – MOET in 2010.

Professional and administrative highlights (2010–2012) during this period are given below—

**Professional Highlights**

- Established a government authorised camel embryo transfer laboratory in Abu Dhabi.
- Achieved an average of 6 viable embryos per super ovulation with a 60% embryo transfer success rate.
- Prepared recipient camels and performed embryo transfers as part of advanced MOET programs.
- Managed infertility and gynecological cases across multiple veterinary clinics: Al Samha, Al Wathba, and Al Wafia.
- Developed and implemented Standard Operating Procedures (SOPs) for camel embryo production and transfer.

**Administrative Highlights**

- Led the MOET department, overseeing laboratory operations and clinical services.
- Coordinated cross-clinic activities and ensured adherence to government standards.
- Standardised procedures and protocols for reproductive biotechnology in camels.
- Contributed to capacity building within the ADFCA veterinary teams.

This hands-on experience with camels led me to my current role in Dubai, where I am honoured to serve as a Senior Scientist and Head of the Multiple Ovulation and Embryo Transfer (MOET) Department at the Reproductive Biotechnology Centre. Under the vision, support and guidance of His Highness Sheikh Hamdan bin Mohammed bin Rashid Al Maktoum, the Crown Prince of Dubai and the Deputy Prime Minister of UAE, I have been able to contribute groundbreaking research in camel reproductive biotechnology (Fig 5).

My work focuses on advanced reproductive techniques, including MOET, the production of mature oocytes through superstimulation and ultrasound-guided ovum pickup (OPU), and the transfer of both MOET-derived and cloned embryos. The oocytes collected through OPU are primarily utilised for laboratory embryo production via somatic cell nuclear transfer (SCNT) and various research projects in our well-equipped and modern laboratory at the centre (Fig 6).

One of the highlights of my work in Dubai has been the establishment of state-of-the-art facilities for MOET, where we have successfully collected embryos from prized racing and beauty camels. The work we have done here producing embryos through MOET and SCNT, transferring them to surrogate mothers, and achieving impressive success rates has set new standards for camel breeding programs in the region.

I joined CVRL, Dubai, UAE, as Senior Scientist and Department Head – MOET, Reproductive Biotechnology Centre in 2012.

Professional and administrative highlights (2012–Present) during this period are given below—

**Professional Highlights**

- Conducted superstimulation protocols in camels and performed ultrasound-guided Ovum Pick-Up (OPU) for *in vitro* embryo production via nuclear transfer.
- Prepared recipient camels with hormonal treatments and successfully transferred cloned embryos, achieving remarkable pregnancy success rates.
- Established MOET facilities at the Reproductive Biotechnology Centre for high value racing and beauty camels.
- Achieved a 60% embryo transfer success rate in MOET programs with elite donor camels.

**Administrative Highlights**

- Headed the MOET department, overseeing laboratory operations, clinical programs, and research coordination.
- Managed high value donor camels and surrogate programs, ensuring quality and consistency in embryo production.
- Developed and standardised protocols for camel MOET and embryo transfer programs.
- Coordinated multidisciplinary teams, including veterinarians, technicians, and researchers, to ensure smooth operational and research workflows.
- Contributed to the strategic growth and research output of the Reproductive Biotechnology Centre.

With extensive practical experience in administration and management, I sought to strengthen my theoretical understanding of key organisational functions, including production,

**Fig 1.** Cattle Embryo Transfer Laboratory established at Mattupatti under the KLDB marked a significant milestone in advancing reproductive biotechnology in Kerala. The achievement was reported in Malayalam daily newspapers and magazines (http://doi.org/10.13140/RG.2.1.2889.0721, http://doi.org/10.13140/RG.2.1.3937.6487)

marketing, finance, and human resources. To achieve this, I successfully completed a Veterinary Practice Management course in the USA. As a scientist, I place great importance on professional ethics. For my course project, I chose the topic of Professional Ethics, and based on the project and subsequent review, I published a manuscript in an international journal, contributing to the discourse on ethical practices in veterinary and reproductive biotechnology fields (Vettical, 2018).

Since 2010, I have led advanced camel reproductive biotechnology programs in the UAE. At ADFCA, Abu Dhabi (2010–2012), I established a government-authorized camel embryo transfer laboratory, achieving 6 viable embryos per super ovulation with 60% transfer success, while managing infertility cases and developing SOPs for embryo production and transfer. At CVRL, Dubai (2012–present), as Senior Scientist and Department Head

**Fig 2.** India's first ethylene glycol direct frozen embryo transfer calf, born on 23 June 1996, marking a major milestone in advanced bovine reproductive biotechnology in India. Reported in Malayalam daily newspapers (http://doi.org/10.13140/GG.2.1.4724.0802)

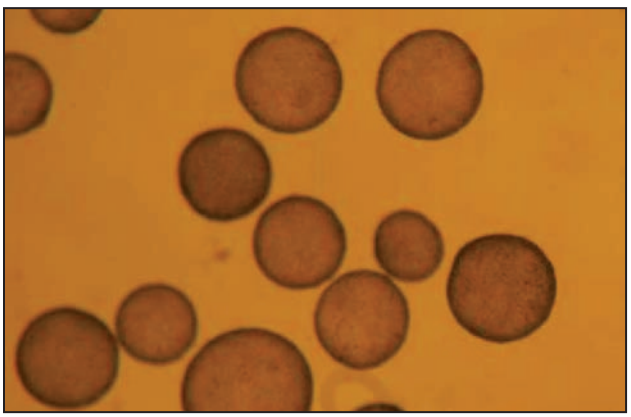


**Fig 3.** First-ever experience with camel embryos—achieved through meticulous fieldwork, self-training, and protocol standardization, marking a key step in advancing camel reproductive biotechnology.

– MOET, I established MOET facilities for elite racing and beauty camels, performed super ovulation, OPU, and embryo transfers, consistently achieving 60% success for MOET embryos and significantly improving cloned embryo transfer success, advancing camel reproductive biotechnology in the region. The unexpected nature of my career path has been matched by the remarkable advancements in camel science that I have been privileged to contribute to. My research has led to numerous publications in esteemed journals such as Reproduction Fertility and Development, Theriogenology, Animal Reproduction Science, Zygote, and Journal of Agricultural and Environmental Ethics. Topics range from the effects of body condition on embryo transfer success in camels to the pioneering work on the first cloned Bactrian camel calf produced

**Fig 4.** Milestone in camel reproductive biotechnology—first camel calf born via embryo transfer in the newly developed centre, achieved through intensive research and fieldwork in a short span, leveraging prior bovine experience and expertise.

My work with camels has become not just a career but a passion—one that blends the latest in reproductive biotechnology with the age-old traditions of camel breeding in the desert (Fig 7).

Though my path may have been an unexpected one, it has been deeply fulfilling. Today, I proudly stand as a student of the desert giants, learning from these resilient animals while striving to contribute to the scientific understanding and conservation of camels. The journey continues, and I can only look forward to what lies ahead in this exciting and ever-evolving field.


## Acknowledgements

I sincerely thank His Highness Shaikh Hamdan bin Mohammad bin Rashid Al Maktoum, Chairman of the Executive Council, Crown Prince of Dubai, and Minister of Defence and Deputy Prime Minister of the United Arab Emirates, for his visionary leadership, continued support, and funding. I also extend my gratitude to Dr. Ali Redha, Director General, and Dr. Wani NA, Scientific Director, for their guidance and encouragement. I am deeply thankful to my mentors, who have profoundly

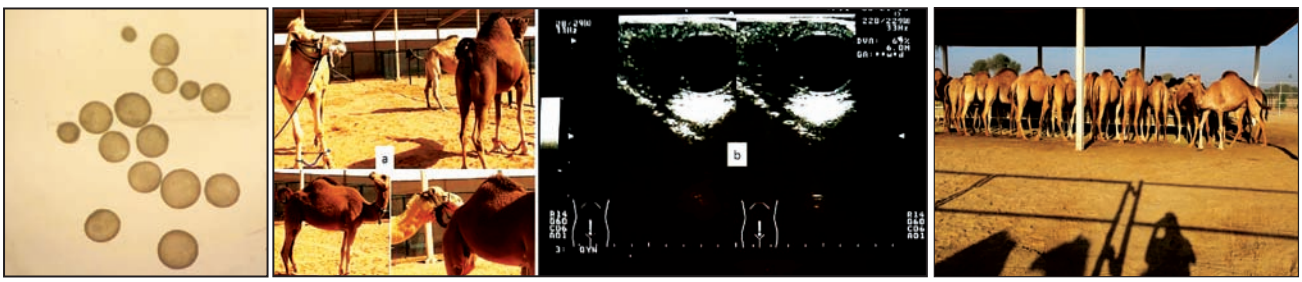



**Fig 5.** Advancing camel reproductive biotechnology at Dubai's Reproductive Biotechnology Centre—from embryo production and early pregnancy diagnosis by male parade on the seventh day after embryo transfer to subsequent ultrasound confirmation—enhancing the outcomes of MOET and SCNT techniques.

**Fig 6.** Honoured to share a moment with His Highness Sheikh Hamdan bin Mohammed bin Rashid Al Maktoum, Crown Prince of Dubai and Deputy Prime Minister of UAE—a true animal lover and inspiring leader who beautifully bridges innovation and tradition.

through inter species somatic cell nuclear transfer, a project that holds promise for preserving endangered camel species (Vettical *et al,* 2016; Wani *et al,* 2017a, 2017b; Wani *et al,* 2018; Vettical *et al,* 2019; Hong *et al,* 2020; Vettical and Wani, 2021a, 2021b).

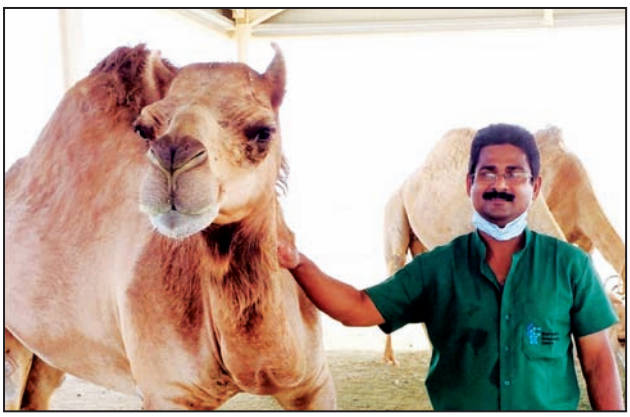


**Fig 7.** From the lush fields of Kerala to the golden dunes of the UAE, my journey with camels has turned childhood curiosity into a lifelong passion—where science meets desert tradition.

**Key Achievements & Measurable Results in Cattle and Camel Embryo Transfer Biotechnology.**

| Program | Period | Key Procedures | Output/ Results |
|---|---|---|---|
| MOET Cattle | 1991-2010 | 350+ Superovulations & Flushings | 2,500+ Embryos |
| | | 700+ Embryo Transfers | 350+ Pregnancies |
| MOET Camels | 2011-2018 | 70+ Superovulations & Flushings | 400+Embryos |
| | | 350+ Embryo Transfers | 175+ Pregnancies |
| OPU Camels | Since 2013 | 1000+ OPU Procedures | 10,000+ Usable quality Oocytes Retrieved |
| Cloned Embryo Transfer | Since 2013 | 2,800+ Embryo Transfers | 250+ Pregnancies |

influenced and inspired my career in reproductive biotechnology, particularly Dr. Abraham Mathew (M.V.Sc, FRCVS), a renowned expert in large-scale frozen semen technology in India, under whom I began my career, and Dr. Peter Reichert, whose mentorship was pivotal in refining my expertise in embryo transfer and allied technologies. I also thank Dr. V. Vijayakumaran, Chairman of the Advisory Committee during my post-graduate studies, for his guidance. I extend my heartfelt gratitude to Dr. Tarun Kumar Gahlot for his unwavering support and encouragement, which not only enabled me to serve as a member of the Editorial Board of the Journal of Camel Practice and Research but also made the publication of this article possible. Finally, I extend heartfelt appreciation to all my supportive staff members, without whom these achievements would not have been possible.

## Funding

The funding was not required for this write-up of personal experience.

## Data Availability

The data generated during the study can be requested from the corresponding author.

## Conflict of Interest

The author declare no conflict of interest.

## References

### International Journals

Hong SB, Vettical BS and Wani NA. Development of prepubertal goat oocytes after their *in vitro* maturation and chemical activation. Zygote. 2020; 28(6):447–452. https://doi.org/10.1017/S0967199420000313

Vettical BS and Wani NA. Body condition of donor animals and recipients affects the outcome of embryo transfer programs in dromedary camel (*Camelus dromedarius*). Reproduction Fertility and Development. 2021b; 33:144–145. https://doi.org/10.1071/RDv33n2Ab74

Vettical BS and Wani NA. In vivo versus *in vitro* embryo production after superstimulation of donors in the camel (*Camelus dromedarius*). Reproduction Fertility and Development. 2021a; 34:269–270. https://doi.org/10.1071/RDv34n2Ab67

Vettical BS, Hong SB and Wani NA. Multiple ovulation and embryo transfer (MOET) in camels: An overview. Asian Pacific Journal of Reproduction. 2016; 5(2):102–104. https://doi.org/10.1016/j.apjr.2016.01.003

Vettical BS, Hong SB, Muhammad AU and Wani NA. Comparison of pregnancy rates with transfer of *in vivo* produced embryos derived using multiple ovulation and embryo transfer (MOET) with *in vitro* produced embryos by somatic cell nuclear transfer (SCNT) in the dromedary camel (*Camelus dromedarius*). Animal Reproduction Science. 2019; 209:106132. https://doi.org/10.1016/j.anireprosci.2019.106132

Vettical BS. An overview on ethics and ethical decision making process in veterinary practice. Journal of Agricultural and Environmental Ethics. 2018; 31:739–749. https://doi.org/10.1007/s10806-018-9752-5

Vettical BS. Effect of fetal calf serum and mid-estrus cow serum on *in vitro* maturation and fertilisation of oocytes from crossbred cattle in the tropics. International Journal of Applied Sciences and Biotechnology. 2016b; 4(3):308-310. https://doi.org/10.3126/ijasbt.v4i3.15149

Vettical BS. Evaluation of cauda epididymal semen quality of crossbred bulls in the tropics. International Journal of Applied Sciences and Biotechnology. 2016c; 4(1):130–132. https://doi.org/10.3126/ijasbt.v4i1.14253

Vettical BS. *In vitro* fertilizability of oocytes using fresh, frozen and epididymal spermatozoa from crossbred bulls in the tropics. International Journal of Applied Sciences and Biotechnology. 2016a; 4(2):166–171. https://doi.org/10.3126/ijasbt.v4i2.14265

Wani NA, Hong SB and Vettical BS. Cytoplast source influences development of somatic cell nuclear transfer (SCNT) embryos *in vitro* but not their development to term after transfer to synchronised recipients in dromedary camels (*Camelus dromedarius*). Theriogenology. 2018; 118:137-143. https://doi.org/10.1016/j.theriogenology.2018.05.021

Wani NA, Vettical BS and Hong SB. First cloned Bactrian camel (*Camelus bactrianus*) calf produced by interspecies somatic cell nuclear transfer: A step towards preserving the critically endangered wild Bactrian camels. PLoS ONE. 2017a; 12(5): e0177800. https://doi.org/10.1371/journal.pone.0177800

Wani NA, Vettical BS and Hong SB. Recent advances in cloning by somatic cell nuclear transfer in camelids. Reproduction Fertility and Development. 2017b; 30:156. https://doi.org/10.1071/RDv30n1Ab34

## National/International Conferences and National Journals


Vettical BS, Kuruvila V, Muraleedharan K and Harisankar S. Cryopreservation of embryos in ethylene glycol freeze media and direct transfer in crossbred cattle in the tropics. In: Proceedings of the 9th International Congress on Biotechnology in Animal Reproduction. 2002a; pp 40. DOI: http://doi.org/10.13140/RG.2.1.2072.3049

Vettical BS, Kuruvilla V and Harisankar S. Significance of embryo transfer technology in breeding bull stations to support breeding operations in India. In: Proceedings of the 9th International Congress on Biotechnology in Animal Reproduction. 2002b; PS-1/09.211. http://doi.org/10.13140/RG.2.1.4955.8880

Vettical BS, Kuruvilla V, Muraleedharan K and Harisankar S. Embryo transfer technology for exotic bull production – a substitute for direct import of bulls to support crossbreeding in the tropics. In: Proceedings of the 9th International Congress on Biotechnology in Animal Reproduction. 2002c; PS-1/08.210. http://doi.org/10.13140/RG.2.1.2858.7368

Vettical BS, Raji RJ, Metilda J and Kuruvilla V. Effect of season on super ovulation and embryo harvesting in crossbred cows under different agroclimatic zones. In: Proceedings of the 9th International Congress on Biotechnology in Animal Reproduction. 2002d; PS-1/07.210. http://doi.org/10.13140/RG.2.1.4431.6009

Vettical BS and Das AS. Commercial production of sex-sorted semen for prediction of sex and its scope. In: Proceedings of the XIII Annual Convention of Indian Society for Veterinary Immunology and Biotechnology and National Symposium on Veterinary Biotechnology and Immunology for Sustainable Rural Livestock Security. 15-17 February 2007; pp 40. https://doi.org/10.5281/zenodo.18707786

## CAMEL MILK EXTRACELLULAR VESICLES AS A PROMISING ANTIBIOTIC ALTERNATIVE

The increasing demand for sustainable alternatives to in-feed antibiotics in animal production underscores the scarcity of thorough research on natural bioactive carriers that endure gastrointestinal digestion and offer multiple benefits. This study explored the potential of camel milk extracellular vesicles (CM-EVs) as natural alternatives to antibiotics in animal production. The research evaluated the gastrointestinal stability and multifunctional properties of CM-EVs through *in vitro* analysis. Simulated digestion experiments revealed that CM-EVs maintained their structural integrity throughout the gastrointestinal tract. Furthermore, they exhibited significant dose-dependent antioxidant activity and demonstrated effective antimicrobial properties against *Escherichia coli* and *Staphylococcus epidermidis*. In macrophage models, CM-EVs enhanced cell viability and selectively reduced the release of IL-1β and IL-6, without affecting TNF-α levels. These results indicated that CM-EVs are stable during digestion and possess antioxidant, antimicrobial, and immunomodulatory properties, highlighting their potential as a natural supplement to enhance animal health and reduce reliance on conventional antibiotics.

(Source: Fu J., Fu L., Zhai B. *et al*. Camel milk extracellular vesicles as a promising antibiotic alternative: gastrointestinal stability, antimicrobial, and immunoregulatory activities. Sci Rep 16, 8903 (2026). https://doi.org/10.1038/s41598-026-42021-0)

## WHOLE-GENOME SEQUENCES OF RACING CAMELS

Racing dromedary camels are widely distributed across the Arabian Peninsula, predominantly concentrating in its northern and southeastern regions. Phenotypically, they are differentiated from other dromedary types, characterised by their smaller body size, longer limbs, reduced hump size, and thinner chest girth. In this study, the whole genome sequences of 34 racing camels were analysed to assess their genetic relationship with non-racing populations, estimate levels of inbreeding, calculate Wier and Cockerham's fixation index (Fst), assess effective population size (Ne), and identify candidate regions with signatures of positive selection. Both racing and non-racing camels exhibited comparable levels of genomic inbreeding (FROH = 0.21), with no significant genetic differentiation detected between them. The estimated Fst value between the two camel groups also revealed minimal genetic differentiation. A declining trend was observed in Ne estimations of both groups over the past 5 000 years, with slightly lower recent Ne in racing camels compared to their non-racing counterparts. Signatures of positive selection in the genomes of racing camels were identified through the application of two haplotype-based statistics, namely the integrated haplotype homozygosity score (iHS) and extended haplotype homozygosity between-populations (Rsb), along with runs of homozygosity (ROH) analysis. A total of 33 regions under selection were detected via iHS, 19 via Rsb, and 24 through ROH. Candidate regions under selection were found to overlap with genes involved in diverse biological pathways potentially linked to athletic performance, e.g., musculoskeletal development, lipid metabolism, stress response, bone integrity, as well as endurance and power. These findings provide a foundation for further exploration of the racing dromedary genome, with the goal of defining variants and haplotypes that might be associated with athletic traits. Such insights could assist the development of genetically informed breeding programmes aimed at developing specialised racing dromedary lines, contributing to the broader understanding and preservation of animal athletic performance and selection in domesticated species worldwide.

(Courtesy: Bahbahani, H., Mohammad, Z., Alfoudari, A. and Al Abri, M. Genomic insights into racing camels: inbreeding levels and positive selection linked to athletic traits. 2025. Animal 19 (4) SP 101467, https://doi.org/10.1016/j.animal.2025.101467)

DOI : 10.5958/2277-8934.2026.00012.5 Vol 33 No 1, p 93-96

# CLINICAL CASE REPORT: EYEBALL ENUCLEATION IN A FEMALE LLAMA (*Lama glama*)

**Amusquibar M.V.[1,2], Bertuzzi M.[1,2], di Fonzo A.[1], Zampini E.[1,2], Gallelli M.F.[1,2], Carretero M.I.[1,2], Trasorras V.[1,2], Neild D.M[1] and Arraztoa C.C.[1]**

[1]Universidad de Buenos Aires (UBA), Facultad de Ciencias Veterinarias (FCV), Instituto de Investigación y Tecnología en Reproducción Animal (INITRA), Cátedra de Teriogenología, Buenos Aires, Argentina

[2]Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), Buenos Aires, Argentina

## ABSTRACT

This case report describes the diagnosis, surgical treatment and progression of an ocular lesion in a llama. A 4-year-old female llama was presented with epiphora, blepharospasm and corneal rupture in the left eye, suggestive of trauma-induced corneal perforation. Due to the severity of the lesion and the risk of secondary complications, enucleation of the eyeball was performed using a transpalpebral technique under general anaesthesia. Postoperative management included systemic analgesics, antibiotics and the gradual removal of cambric-type gauze impregnated with antibiotics from the orbital cavity, which promoted controlled granulation tissue formation and uncomplicated healing.

**Key words:** Eyeball enucleation, *Lama glama*, ophthalmic pathologies, South American camelids, transpalpebral technique

The most frequent ophthalmological diseases in South American Camelids (SAC) are trauma, congenital and acquired diseases, conjunctivitis, corneal ulcers, cataracts, lens subluxation and vitreous opacity (Gelatt *et al,* 1995). Webb *et al* (2006) provided valuable information by defining that there is a slight tendency in llamas and alpacas to develop hereditary eye diseases, the most frequent being persistent pupillary membrane, cataracts and corneal dystrophies. Currently there is an increase in the reports of eye diseases, which could be due to a greater diagnosis or to an increase in the prevalence of these diseases as a result of inbreeding (Gionfriddo, 2010).

## Case history

In this study we report the diagnosis and treatment of an eye condition in a 4-year-old female llama of 120 kg. The animal was housed at the Faculty of Veterinary Sciences of the University of Buenos Aires, Argentina. On examination, vital parameters were normal and on inspection, the left eye had epiphora and blepharospasm, with a wound showing loss of continuity and extrusion of a transparent content of viscous appearance (Fig 1). It possibly occurred due to traumatic injury which had perforated the cornea. It was decided to provisionally perform a third eyelid and tarsorrhaphy as the ocular lesion which was too extensive to resolve with second-intention healing (Fig 2). Since the corneal perforations was deep an extensive it was decided to perform the enucleation of the eyeball. The topical treatment was given for 4 days pre-operatively (Table 1).

## Surgical technique

General anaesthesia was induced by administration of 10% xylazine (PRO-SER®) at a dose of 0.2 mg/kg, and ketamine (PRO-SER®) at 1.5 mg/kg intravenously. 2% lidocaine (Equi Systems®) was infiltrated subcutaneously (Fig 3A). Subsequently the periorbital region was shaved, the eyelashes were trimmed, and an initial antisepsis was performed with 4% chlorhexidine digluconate. Enucleation was done by transpalpebral technique and the eyeball, conjunctiva and nictitating membrane were removed as a single mass (Fig 3B). Two Backhaus forceps were used to hold the eyelids. Then, an elliptical incision was made around the eye, approximately 5 mm from the eyelid margins. Subsequently, blunt dissection was performed by Mayo scissors to separate the subcutaneous eyeball tissues. The medial and lateral canthal ligaments were cut by curved Mayo scissors. It was followed by blunt dissection of the extraocular

SEND REPRINT REQUEST TO AMUSQUIBAR M.V. email: mvamusquibar@fvet.uba.ar

muscles peripheral to the sclera. The orbit vasculature and optic nerve were ligated independently, using laparoscopic extracorporeal knots. Finally, the eyeball was removed, together with the rim of the eyelids and adnexa. The orbit cavity was filled with approximately 2 m of cambric-type bandage, soaked in sulfadiazine, and placed in a zigzag manner. Lastly, the wound was covered with gauze, cambric bandages and 3M VetRap bandages (3MTM), and sprayed with an external antiparasitic aerosol.

### Postsurgical care

The female was kept in a small pen with two other llamas. She was checked every 24 h and the wound was irrigated with saline solution and dried with sterile gauze. The cambric-type bandage that filled the cavity was progressively removed, to generate the gradual growth of granulation tissue in the orbital cavity. The rate of removal was 40 cm per day, over 5 days. Topical and systemic treatments used are described in Tables 1 and 2, respectively. The wound healed completely 1 month after surgery (Fig 4) and the llama returned to the general herd, without any complications either during or after the treatment.

**Table 1.** Topical treatment prior to surgery.

| Eyedrops | Dose | Dosage | Duration |
|---|---|---|---|
| Tobramycin 0.3% | 3 drops | every 24 h | 4 days |
| Gatifloxacin 0.3% | 3 drops | every 24 h | 4 days |
| Phenylephrine HCI 5% + Tropicamide 0.5% | 3 drops | every 24 h | 4 days |

Eyedrops were administered 15 minutes apart.

**Table 2.** Postoperative systemic treatment.

| Medication | Dose | Dosage | Duration |
|---|---|---|---|
| Ranitidine 20 mg/ml | 1.5 mg/kg | IM – every 24 h | 10 days |
| Tramadol 60 mg/ml | 3 mg/kg | IM – every 24 h | 6 days |
| Amoxicillin 15 g | 15 mg/kg | IM – every 48 h | 10 days |
| Meglumine flunixin 50 mg/ml | 2.2 mg/kg | IM – every 24h | 4 days |
| Ivermectin 1% | 0.5 mg/kg | SC – every 7 days | 21 days |

IM: intramuscular, SC: subcutaneous

### Discussion

The llama of present study had a traumatic deep laceration of cornea which was managed through enucleation. However, ocular disorders in South American camelids include corneal ulceration, keratitis, conjunctivitis, cataracts, and traumatic injuries of the eyelids and globe (Fowler, 2010; Anderson and Miesner, 2018; Gelatt, 2013).

Although it is a technique used infrequently in South American camelids, ocular enucleation constitutes a valid surgical alternative for severe lesions in llamas, including corneal perforation such as reported in this case. Owing to the severity of the eye injury and poor prognosis, enucleation was preferred.

In the present case report, the transpalpebral surgical technique was performed, one of the methods most widely used in equines due to its efficacy in removing the eyeball and adnexa in a single block, reducing the risk of contamination of the orbit (Pollock *et al*, 2008). In horses, this technique has even been performed on standing animals under local anaesthesia, which, for example, reduces gastrointestinal postsurgical complications common in surgeries requiring prolonged recumbency. However, general anaesthesia is preferred in camelids because it provides a safer environment both for the animal and the surgical team. This is because camelids usually have a more sensitive temperament and their anatomy does not help standing management during invasive procedures. They also have a low tolerance to stress and forcing them to remain standing could lead to complications either during or after surgery. The prompt surgical intervention in this case avoided major complications such as self- mutilation, secondary infections or even systemic dissemination to the central nervous system, considering the direct anatomical connection between the eyeball and the optic nerve. The surgical approach also responded to animal welfare criteria, as ocular pain is among the most intense in veterinary medicine and its immediate relief is a priority. Post surgical management was successful, being noteworthy the use of a cambric-like bandage soaked in antibiotic and located in the orbital cavity and then progressively removed. Although this strategy is used in other species, we have not found a report of its use in South American camelids, thus providing a valuable reference for similar future interventions. This technique favoured the controlled formation of granulation tissue, leading to uncomplicated healing. Fugaro *et al* (2005) have reported a case where transpalpebral enucleation was performed to remove a diseased eye in a llama.

The transpalpebral enucleation technique, which involves removal of the eye with the eyelids sutured closed, has been described in camelids such as llamas and alpacas in case reports involving

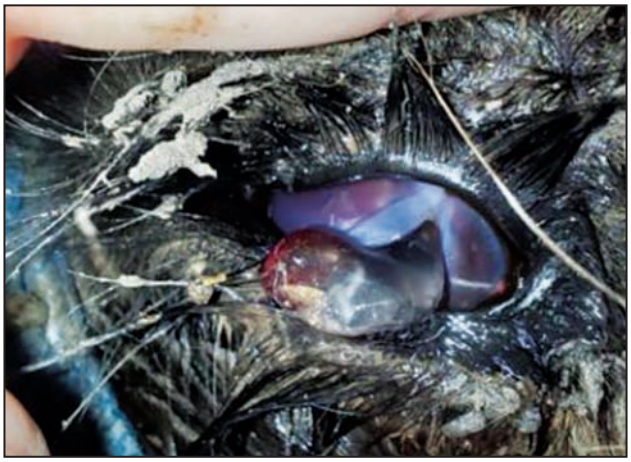


**Fig 1.** Left eyeball wound. Corneal perforation.

**Fig 2.** Third eyelid flap.

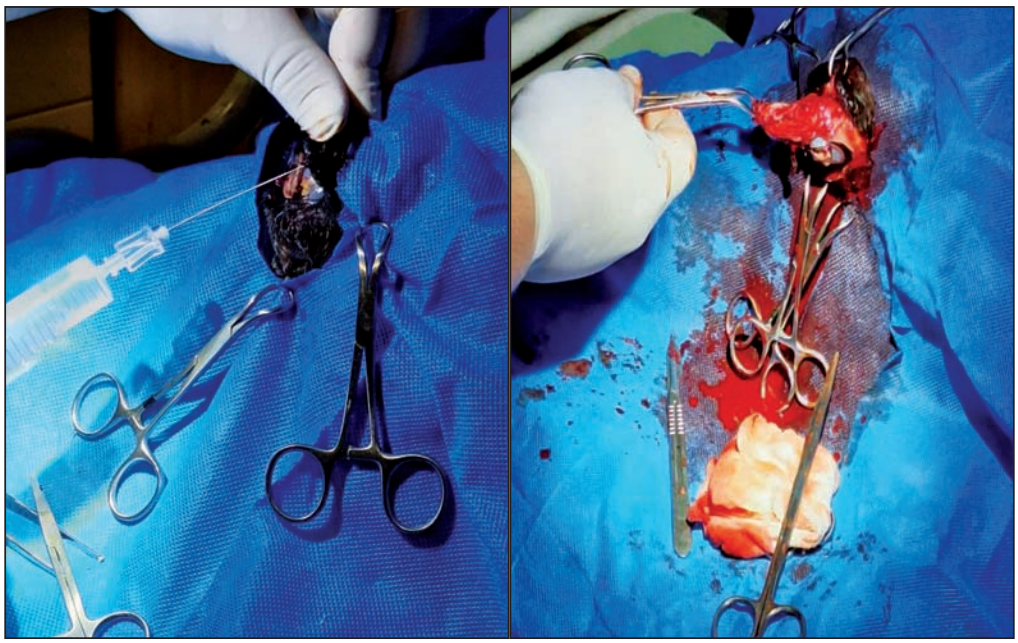


**Fig 3.** Surgical procedure: A: Local anaesthesia. B: transpalpebral technique.

**Fig 4.** Correct cicatrisation 30 days after enucleation.

ocular tumors and severe ocular disease (Fugaro *et al,* 2005; Schoeniger *et al,* 2006; Gionfriddo, 2010). Transpalpebral enucleation was performed in a 6 year old llama which had retinoblastoma, and an orbital silicone prosthesis was placed (Fugaro *et al,* 2005). Another report describes surgical removal of the eye in a llama due to an intraocular tumor-medulloepithelioma (Schoeniger *et al,* 2006).


## Funding

Funding provided by the following Project: PICT-2020-SERIEA-014 78

## Acknowledgements

The authors would like to thank Dr. Cristian Montes de Oca, for his selfless cooperation in the practice of llama surgery, as well as Dr. Santiago

Parrinello for his collaboration in the animal's ophthalmologic examination.

## Conflict of interest

The authors declare no conflicts of interest.

## Author Contributions

Claudia Arraztoa: was involved in doing the experiments and writing the paper. María Ignacia Carretero, Trasorras Virginia and Galleli Florencia: They participated in the treatment and were also involved in critically revising the manuscript for important intellectual content. Bertuzzi Mariana, di Fonzo Andrea and Zampini Enzo: collaborated in the experiments. Deborah Neild: supervised the research and translated and critically read the manuscript.

## References

Czerwinski SL. Ocular surface disease in New World camelids. Veterinary Clinics: Exotic Animal Practice. 2019; 22(1), 69-79. doi: 10.1016/j.cvex.2018.09.001

David E. Anderson DE, Jones ML and Miesner MD. Ophthalmic examination and procedures in llamas and alpacas. In: Veterinary Techniques in Llamas and Alpacas. Ames (IA): Wiley-Blackwell; 2013. pp 287-305.

Fowler ME. Ocular diseases and disorders of special senses in camelids. In: Medicine and Surgery of Camelids. 3rd ed. Ames (IA): Wiley-Blackwell; 2010. pp 455-470.

Gelatt Kirk N, Gilger Brian C and Kern Thomas J (Eds). Ophthalmology of camelids. In: Veterinary Ophthalmology. 5th ed. Ames (IA): Wiley-Blackwell; 2013.

Fugaro MN, Kiupel M, Montiani-Ferreira F, Hawkins JF, Janovitz EB. Retinoblastoma in the eye of a llama (*Llama glama*). Veterinary Ophthalmology. 2005; 8(4):287-290

Gelatt KN, Otzen Martinic GB, Flaneig JL, Schein OD, Muñoz B, West SK, Duncan DD, Nethercott JR, Koren HS. Results of ophthalmic examinations of 29 alpacas. Journal of the American Veterinary Medical Association. 1995; 206(8):1204-1207

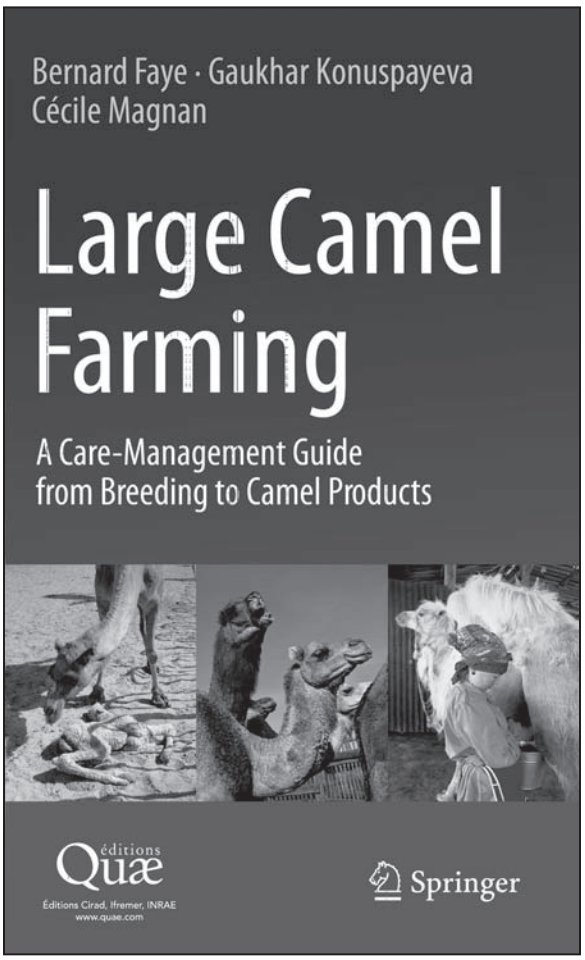
Gionfriddo JR. Ophthalmology of South American camelids. Veterinary Clinics of North America. Food Animal Practice. 2010; 26(3):531-55. doi: 10.1016/j.cvfa.2010.08.004.

Pollock PJ, Russell T, Hughes TK, Archer MR, Perkins JD. Transpalpebral eye enucleation in 40 standing horses. Veterinary Surgery. 2008; 37(3):306-309. doi: 10.1111/j.1532-950X.2008.00382.x.

Schoeniger S, Donner LR, Van Alstine WG. Malignant non-teratoid ocular medulloepithelioma in a llama (*Llama glama*). Journal of Veterinary Diagnostic Investigation. 2006;18:499-503.

Webb AA, Cullen CL, Lamont LA. Brainstem auditory evoked responses and ophthalmic findings in llamas and alpacas in Eastern Canada. The Canadian Veterinary Journal. 2006; 47(1):74.

# BOOK REVIEW




Nowadays, camel farming has undergone a major transformation which is not unrelated to the dual challenge of climate change and economic globalisation. Such process induced a remarkable evolution of breeding methods and significant changes in the management of this animal, which are not without effects on its physiology and health. Long time devoted to marginal economy, camel breeding and its products are experiencing a real craze that goes beyond the borders of arid countries. Although the services of the camel have probably been provided by desert people for thousands of years, it is only recently that products (milk, meat, wool, hides, sport) have entered the international economy, that production systems have intensified, and that the processing of these products has been modernized. However, to be embarked on the adventure of camel production outside the traditional breeding areas and management, it is necessary to provide products and services that meet the standards of the twenty-first-century consumers. There are also more veterinarians who are confronted with the health management and care of an animal that has suddenly been subjected to unusual forms of breeding.

This book aims to give some guidance, if not to succeed in the sharing of the experience of camel breeding with full knowledge of the facts and to support all the actors of a fast-growing sector, including veterinarians. This publication does not claim to be exhaustive, but it hopes to be useful to breeders who wish to market products that are rightly or wrongly reputed to be beneficial, as well as to veterinarians and decision-makers who see the camel nowadays ready to be part of agro-ecosystems that are less restrictive than its original desert.

Thus, this book which was already translated in French, Spanish, Turkish, Arabic and Russian, describes the generalities about the species, the physiological bases of reproduction, lactation and feeding, the main productions, as well as the management of health and hygiene in camel farming.

**The authors:**

**Bernard Faye,** veterinarian and doctor of the University PARIS XII, is an INRAE research engineer and currently emeritus expert at CIRAD. As a specialist in camel breeding and production, he brings more than 45 years of experience with this species. He is also author of Camel Clinical Biochemistry and Hematology (Ed. Springer, 2018).

**Gaukhar Konuspayeva** (Al-Farabi University in Almaty, Kazakhstan) is a bio-chemist and doctor of the University of Montpellier. She serves as a consultant for FAO and has been a visiting researcher at CIRAD. Gaukhar is a specialist in camel milk and processing.

## REVIEW ON NEOPLASIA IN DROMEDARIES

The relative frequencies of tumours in camels were as follows: skin (54.8%), reproductive (23.0%), lymphoid (6.9%), and gastrointestinal (6.3%). The common malignant and benign tumours were observed in the following order: carcinomas (35.5%), fibromas (11.2%), teratomas (7.8%), lymphomas and leukemia (7.4%), papillomas (6.2%), and adenomas (6.2%). A recent rise in tumour cases was observed. Different tumour types were reported in various body systems of the dromedary, with carcinomas, fibromas, teratomas, lymphomas/leukemia, and papillomas being the most common. An increase in tumour reports in camels is expected due to recent advancements in camel farming systems, specialised breeding centers, improvements in veterinary services, and enhanced disease surveillance. Some skin tumours, such as papillomas/fibropapillomas, exhibited koilocytosis, possibly caused by different PV strains, which may warrant further investigation. Abattoir tumour surveys may show bias, as dromedaries presented for slaughter were typically barren females or young males. Various diagnostic methods were discussed, and future advanced technologies for tumour diagnosis and treatment in camels, including targeted therapy and precision medicine, were suggested.

(Source: Abu Damir H, Tageldin MH, Ali MA, Adem A. Neoplasia in the dromedary camel: a review (Camelus dromedarius). Front Vet Sci. 2025 Dec 10;12:1664874. doi: 10.3389/fvets.2025.1664874. PMID: 41451336; PMCID: PMC12731250.)

## LARGE-SCALE EMBRYO TRANSFER OPERATION IN DROMEDARY CAMELS

ET is used in camel reproduction to increase the reproductive potential of elite females selected for production and show. This retrospective study analysed the association between factors related to embryo flushing (flushing fluid turbidity and debris), embryo quality (grades 1–4), recipient uterine status (tone and endometrial microcalcifications (EM)), farm and its locations (Qassim and Hail), as well high and low temperature on the likelihood of establishment of the 2-month pregnancy rate (PR) in dromedary camels. A total of 4360 embryos were transferred to 2947 recipients in this study. Logistic regression analysis (binary) was applied to evaluate the association between the selected factors and PR in month two. The likelihood of PR was affected by embryo quality ($p < 0.01$), EMs ($p < 0.01$), and farm ($p < 0.05$) and its location ($p < 0.01$). Transferring embryos to low ($p < 0.01$) or medium ($p < 0.05$) EM recipients decreased the likelihood of PR by ~1.3 times compared to uteri without EM. Grade 3 or 4 embryo transfer decreased the likelihood of PR by ~1.9 and 2.6 times, respectively, compared to grade 1 embryos ($p< 0.01$). In Saudi Arabia, applying an ET program in dromedaries in the Hail region raised the prediction of PR over the Qassim region by 1.2 times. Temperature changes had no effect on PR; however, higher temperature only affected the PR when grade 4 embryos were transferred. In conclusion, the likelihood of PR was higher with the transfer of grade 1 or 2 embryos in an EM-free uterus in the Hail region (Saudi Arabia). PR was only affected by higher temperature in the case of transferring grade 4 embryos.

(Source: Osman TK, Ismail ST, El-Sherbiny HR. Large-Scale Embryo Transfer Operation in Dromedary Camels: Retrospective Analysis of the Association Between Key Clinical Factors and the 2-Month Pregnancy Rate. Animals (Basel). 2025 Jun 24;15(13):1859. doi: 10.3390/ani15131859. PMID: 40646758; PMCID: PMC12248810)

# INSTRUCTIONS TO CONTRIBUTORS

**(For the year 2025 to 2027)**

**(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.

**Specific policies regarding retractions, corrections, publishing malpractices, authorship and plagiarism :**

The Journal of Camel Practice and Research has specific policies addressing retractions, corrections, publishing malpractice, authorship, and plagiarism, ensuring the integrity of its published research. These policies generally outline procedures for addressing errors, investigating misconduct, defining proper authorship, and preventing plagiarism.

**Retractions:**

Articles may be retracted if they contain significant errors, ethical violations, or if there is evidence of fabrication or falsification.

**Corrections:**

Minor errors or omissions can be corrected through an erratum or correction notice, ensuring the accuracy of the published work.

**Editor's Note:**

In some cases, an Editor's Note or Editorial Expression of Concern may be issued to alert readers to potential issues with an article while an investigation is ongoing.

**Public Notice:**

Retractions and corrections will be prominently displayed and linked to the original article, ensuring transparency and informing readers of the issues.

**Publishing Malpractice:**

Publishing malpractice includes fabrication, falsification, plagiarism, duplicate publication, and other unethical behaviours. The journal will investigate any allegations of misconduct, often with the assistance of the Editor-in-Chief and potentially involving the COPE guidelines (COPE: Committee on Publication Ethics). Proven misconduct may lead to rejection of a manuscript, retraction of a published article, or other disciplinary measures, including informing superiors, institutions, and funding organisations.

**Authorship:**

Authorship is typically reserved for individuals who have made significant contributions to the conception, design, execution, data analysis, and interpretation of the study.

**Responsibility:**

Authors are responsible for the accuracy and integrity of their work and must be able to take public responsibility for the content.

**Acknowledgements:**

Individuals who contributed to the research but do not meet the criteria for authorship are acknowledged in the "Acknowledgements" section. All the authors need to agree on the name(s) included in the Acknowledgement section.

**Plagiarism:**

JCPR may use plagiarism detection software to screen manuscripts before and during publication. Plagiarism may lead to rejection of a manuscript or retraction of a published article.

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.

**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** (Mycobank) for fungi or **ZooBank** (ZooBank.org) 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 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.

**Reviewer Selection**

The editor in chief identifies qualified experts, ensures impartiality, and maintains confidentiality. It involves subjecting manuscripts to the scrutiny of experts in the field who assess the quality, originality, and relevance of the research. The editor in chief identifies suitable peer reviewer among the members of the editorial board or a guest reviewer having expertise in the subject area. Guest reviewers are also selected by consulting the databases, such as Publons or similar platforms, to identify researchers who have previously reviewed articles in the relevant field. Potential reviewers are selected by evaluating their publication records, academic affiliations, and reputation within the research community. The selected reviewers who possess the necessary expertise but are ensured to be independent and unbiased. Potential conflicts of interest that could compromise the review's integrity is also considered. Conflicts of interest may arise due to personal relationships, collaborative projects, or professional rivalries. Reviewer's affiliations, recent collaborations, and co-publications with the manuscript's authors are scrutinised to ensure an unbiased evaluation.

**Editorial Decisions**

The Editor first assesses the suitability of submitted manuscripts for the journal. The Editor initiates and oversees the peer review process, ensuring the scientific quality of papers. Based on the reviewers' reports and the Editor's own assessment, they make the final decision on acceptance (with or

without revisions) or rejection. 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. 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.

**Editorial oversight and making final decisions on published content**

Under the oversight of the Editor-in-Chief, other members of the Editorial board will make impartial decisions on articles free from conflicts of interest. In cases of potential conflict, submissions will be referred to the Editor-in-Chief or Editorial Board members without such conflicts to ensure an unbiased evaluation.

**Handling Conflicts of Interest**

Editors are responsible for handling potential conflicts of interest, ensuring that they do not participate in decisions related to their own work, family, colleagues, or products/services they have an interest in. Editors ensure that all published content adheres to ethical guidelines and standards. The Editor may also oversee the peer review process for special issues and article collections, ensuring high publishing ethics.

**Addressing Complaints**

The Editor or a designated Editorial Assistant may be responsible for handling appeals and complaints from authors regarding publication decisions.

**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.

**Post-publication correction policies**

These policies typically involve reporting errors, reviewing proposed corrections, and deciding on the appropriate course of action, which might include publishing a correction, erratum, or retraction. The goal is to promptly address errors and ensure the accuracy of published findings. Authors are expected to promptly notify the editorial office if they discover errors in their published work. The corresponding author is usually the primary point of contact for such communications. Readers or other parties can also report errors to the journal. The editorial team, often led by the editor, assesses the reported error and supporting data. Depending on the nature of the error, the proposed correction may undergo additional peer review. The goal is to determine the most suitable way to rectify the error.

**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.

**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 He[1], Li Yi[1], Liang Ming[1], Jun-Wen Zhou[3], La Ba[3], Rigetu Zhao[3] and Rimutu Ji1,[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.

**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 years 2025-2027. 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.

**Copyright:** The copyright of the article will remain with the owner, Dr Tarun Kumar Gahlot and will be governed by the Indian Copyright Act.

**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: