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In This issue

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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.

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JOURNEY OF CAMEL SCIENTISTS TO THE CAMEL SCIENCE

The camel scientists have taken decades to develop the camel science. Their research has led the camel science to grow as manifested by advances in embro transfer, cloning by somatic cell nuclear transfer, development of vaccines and diagnostic techniques, imaging techniques, anaesthesia and surgery, physiology, parasitology, genetics, production, nutrition and camel welfare, which has reached to a new height. The Journal of Camel Practice and Research (JCPR) has envisioned to highlight the Journey of experienced camel scientists and practitioners to the today's camel science. This will be most befitting at the culmination of the International Year of Camelids. It is interesting to note that the leading camel scientists are from those countries which have a few camels only but they worked so hard in the field of camel science that they became an icon to the field of camel science. Their innovations, exclusive research and authored books are testimony to their great contribution in the field of camel science. A series of manuscripts of journey of these scientists would certainly acquaint our readers about their magnitude of work in the camel science. The April 2025, issue of JCPR highlights interesting stories of pioneer camel scientists, namely U. Wernery, B. Faye, Amir Niasari and Ashraf Saber. There will be more descriptions of camel science heroes in the upcoming issues of JCPR.

An analysis of articles of JCPR published in the year 2024 revealed that out of 45 articles the highest score of manuscripts was related to the pathology (17.7%), followed by milk and anatomy (15.5%, each), physiology (8.8%), imaging and genetics (6.6%, each), production and parasitology (4.4%, each) and welfare, surgery, camel archaeology, camelology, trends of camel research, anaesthesia, camel assisted services and nutrition (2.2%, each). Research related to the camel reproduction and infectious diseases was missing in this year. Many interesting and innovative manuscripts were published which included those related to the camel welfare and artificial intelligence for improved diagnosis, therapeutics and health outcomes, camel assisted services, trends of camel research and analysis of articles published, smart phone fundus imaging, camel archaeology and camelology.

Current issue of JCPR has a lead paper on camel milk sector in Mediterranean basin by Dr Bernard Faye and co-authors. It has two papers on the gross anatomy and histology of pancreas of camels from the scientists of Saudi Arabia. Additional two papers on the anatomy of uterus and ovaries are from the scientists of India. Interesting case reports are on caseous lymphadenitis and ruminitis from the scientists of UAE and Saudi Arabia. Interesting paper from Saudi scientists is based on relief of ocular pain by using NSAIDS and electroacupuncture. The papers based on immunology are also from the Saudi Scientists which include aquaporin 5 immunoreactivity and immunophenotype of blood mononuclear cells.

I am thankful to all the authors who contributed their research, as review or clinical papers, generously for the publication in the SCOPUS indexed JCPR which has entered in 32nd year of it's publication. I am sure that all the camel scientists would continue their support to this exclusive journal on camels in future also. The team of editors of JCPR congratulate Dr R. Schuster, for his immense contribution as an eminent parasitologist at CVRL, Dubai, having superannuated, wish him a happy and healthy retired life. His services to the JCPR are unforgettable as an author and reviewer, both.

Happy JCPR reading!

(Dr. Tarun Kumar Gahlot)
Editor

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THE CAMEL MILK SECTOR IN MEDITERRANEAN BASIN

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ABSTRACT

Camel milk is a new product on the market around the Mediterranean Basin (MB). The objective of the paper was to achieve a state-of-the-art regarding the camel milk sector around the MB and its constraints and challenges to overcome. The Southern bank of the MB involves 99.5% of the camel herd *vs* 0.5% only in the European countries. Few data are available in FAO database regarding camel milk production. Only 4 countries, all in north Africa, declared camel milk production: Algeria, Tunisia, Morocco and Libya. The total declared was more than 29,500 tons for 2023 with more than 51% in Algeria and 31% in Morocco. There are challenges for the camel dairy development in the MB. The introduction of camel milk on market is a recent feature, in general all over the world as it was already underlined. Longtime, the camel milk was a part of the "gift economy" contributing to the "subsistence economy" of the nomad people. The current mutation of the camel farming systems is not limited to some rich countries of the Middle East, but is involving also, most of the countries of the MB. Boosted by a growing urban demand in terms of quantity, quality and diversity of the dairy products, boosted also by the differential of price compared to cow milk based notably to the expected health effect of camel milk, the "commodification" of the camel milk is contributing to the emergence of true dairy camel sector at regional level. Camel milk remains a "niche product", even if its recent growth was important. The high price of the product on the market cannot attribute to this product a competitive interest compared to cow milk, even in countries from the south bank of the MB where the camel population is important. Camel cannot be regarded as "the cow of the future" despite its advantages face to the current environmental challenges. However, the margin of development of the camel sector around the MB is not negligible and must be supported by more favourable regulations, notably in Europe. The different segments of the sector (production, processing, distribution) must be able to benefit from administrative and political support in the different concerned countries.

Key words: Camel milk, camel farming, Mediterranean basin

Camel milk is a new product on the market around the Mediterranean Basin (MB). For longtime, limited to the remote desert areas in the Maghreb countries for self-consumption of the nomadic populations in all countries of the southern bank of the Mediterranean Sea. Camel milk is appearing recently on market, not only in the other regions of these countries (northern part of Morocco, Algeria, Tunisia), but also in new countries such as Türkiye or Western Europe (Faye, 2022). The emergence of an international camel milk market based on the availability of milk powder was also observed recently, including in Western Europe (Konuspayeva *et al,* 2022). However, a fine knowledge of the current status of camel milk value chain around the MB faced to different constraints. Firstly, complete data regarding camel population is lacking, notably in Western Europe. Secondly, some countries such as Egypt, Syria, Palestine, or Turkey did not declare camel milk production susceptible to be registered in FAO database. Thirdly, the importance of self-consumption by the households in the southern bank of the Basin is not quantified. In addition of that, the use or processed milk for non-food products, especially cosmetic, which can be important (Morocco, France) is not well documented in national and a fortiori in international database. These constraints make it difficult to accurately assess the situation of the camel milk sector in the region. However, in the frame of the European project CAMELMILK (project 2019-2022 within PRIMA Programme of the EU), some data were compiled by the partners of the project. Thus, the objective of the paper was to achieve a state-of-the-art regarding the

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Table 1. Camel demography in the Mediterranean Basin (source: FAOstat). The population in European countries (in grey) are estimated by the authors.

Country	Camel heads	Density/100 km²	Nb camel/1000hab	Ann. Growth 1961-2023
Algeria	439134	18,44	9,51	2,94
Egypt	193667	19,33	1,69	0,20
Israël*	5619	25,46	0,61	-0,60
Jordan	13788	15,44	1,21	-0,52
Lebanon	131	1,25	0,02	-1,43
Libya	62852	3,75	8,60	-1,19
Morocco + WSahara**	175505	24,63	4,65	-1,22
Syria	33510	18,10	1,42	2,50
Tunisia	239042	146,10	19,59	0,62
Turkiye	1197	0,15	0,01	-1,56
France	900	0,16	0,01	N/A
Italy	300	0,06	0,01	N/A
Spain	4000	1,32	0,07	N/A
Greece	150	0,11	0,01	N/A
Balkan countries	100	0,06	0,01	N/A
TOTAL	1169895	13,49	2,13	0.03

*NB1: Although the camel population is attributed to Israël in FAO database, almost all the camels are belonging to the Palestinian Bedouins

**NB2: From 1961 to 2017, data from Western Sahara were separated from Morocco in FAO database. The entity WSahara has disappeared after 2017 from the database, but the camel population was not included in Morocco. So, for the period 2017-2023, the camel population was estimated based on the former population growth in the entity and added to the Moroccan population.

camel milk sector around the MB and its constraints and challenges to overcome.

Camel population around the Mediterranean Basin

With a total camel herd of around 1.16 million heads, the countries of the MB gathered approximately 2.75 % of the world population based on the available data in the FAO database (FAOstat, 2024) and on the estimation of European population (not registered in the FAO database). A contrasted situation between countries occurred (Table 1). The Southern bank of the MB involves 99.5% of the camel herd vs 0.5% only in the European countries.

But, even among the southern countries, we can distinguish different situations according to different indicators. Countries with high camel density (more than 10 camels /100 km²) include in the order, Tunisia, Israel, Morocco, Egypt, Algeria, Syria and Jordan. Countries with the highest ratio camel/human (more than 5 camels/1000 hab.) include in the order Tunisia, Algeria and Libya (Table 1). Among the 10 countries of the southern bank, six have experienced a negative growth since 1961 (first year of available statistics in FAO database), while two present a positive growth above 2% (in the order Algeria and Syria). The first ones represent 67% of the current camel population *vs* 29.7% only in 1961 (Fig 1). The strongest decline of the camel population was observed in Turkiye (-1.56 %/year) with a fall from 65,390 in 1961 to 1197 in 2023, even if a slight increase is occurring for the last 20 years (Faye, 2020).

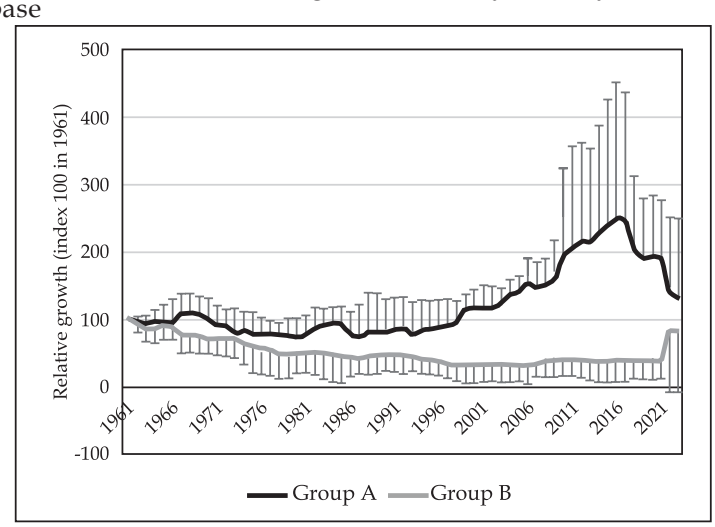

Fig 1. Changes in camel population in the southern bank of the MB, the group A gathering the countries with positive demographic growth (Algeria, Syria and Tunisia), the group B, the other countries of the region with negative growth.

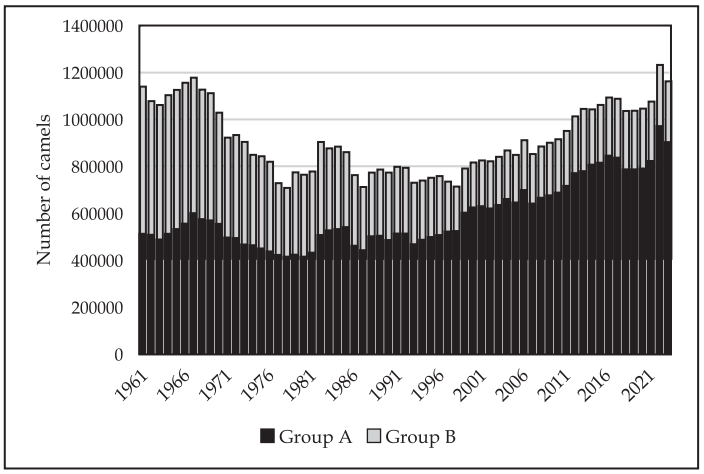

Fig 2. Cumulative histograms showing the changes in camel demography in Southern bank of MB (group A with positive and group B with negative growth)

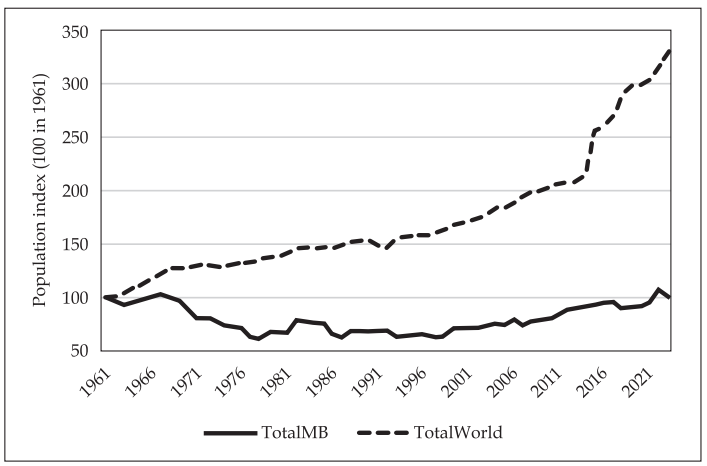

Fig 3. Comparative changes 1961-2021 in camel population around MB and at world level (Source: FAOstat)

Despite this disparity between countries, the global camel population remained stable with an annual growth of 0.03% in the region. However, two phases can be observed: after a regular decline from 1961 to 1998 (-1%/year), the global number of camels around the MB increased by 2.5%/year from 1998 to 2023 (Fig 2). At the same time, the annual camel demography growth 1961-2023 at world level was 3.68% (Fig 3).

It is difficult to know with accuracy the situation in Europe, due to the lack of census and for long time of registration in national and international database (in France, the registration in the national database eSIRECam started in 2018). Except in Canary Islands (Spain), the status of camel in Europe was poorly documented (Wilson and Gutierrez, 2015). Despite of its presence attested since roman empire (Pigière and Henrotay, 2012) and since Middle-age in Italy (Dioli, 2015) or in France (Dierkens, 2005), the "modern" camel was until recently mainly confined in zoological gardens and circus. However, for the last decennials, private farmers were implemented for various activities (tourism, trekking, sport, dairy production) or even as pet animals (Faye *et al,* 1995; Smits *et al,* 2023). Such trends let think that the camel population in Europe is increasing also, especially as the camel meat consumption is not developed leading to the absence of culling of the young males and old females.

Camel milk Production in the MB

Few data are available in FAO database regarding camel milk production. Only 4 countries, all in north Africa, declared camel milk production: Algeria, Tunisia, Morocco and Libya. The total declared was more than 29,500 tons for 2023 with more than 51% in Algeria and 31% in Morocco. The annual growth of the production was 0.64% only for the last 63 years, but with three phases: a first phase of decline from 1961 to 1977 when the milk production fell by −2.17% annually; a second phase from 1978 to 1989 when the production remained stable and a third phase with a positive growth since 1990 by 2.2% annually. However, the situation was very contrasted between these 4 countries. While Algeria experienced a sustained annual growth by 3.8% and Morocco by 1.6%, Tunisia and Libya showed a negative growth, −1.3 and −0.9%, respectively (Fig 4).

The differences in those patterns could be linked to the main purpose of the camel breeding. In Tunisia and Libya, camel farming was mainly devoted to meat production with a very recent development of the milk sector. For example, in Tunisia, the first introduction of the camel milk into market dates from 1995 only (El-Hatmi *et al,* 2003).

To assess the "dairy vocation" of the camel stock, an important indicator was the percentage of lactating camels in the camel herd. Those proportions were 31% in Morocco, 22% in Algeria 17% in Libya and 1.5% only in Tunisia in 2023, i.e., 18.2% for these four countries. At world level, the percentage of producing dairy camels is estimated to 22.5%. If in Algeria, this percentage was stable since 1961 (it was estimated to 24% at this date), the proportion of lactating camels increased by 70% in Libya and by 200% in Morocco. For Tunisia,

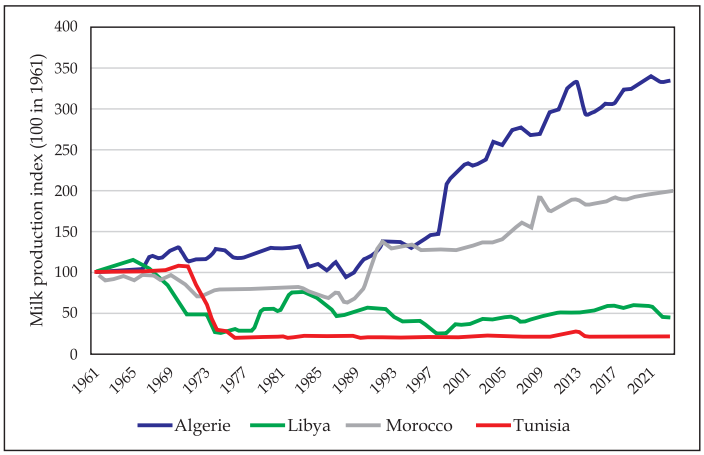

Fig 4. Relative changes in camel milk production in 4 countries of MB 1961-2021 (Source: FAOstat).

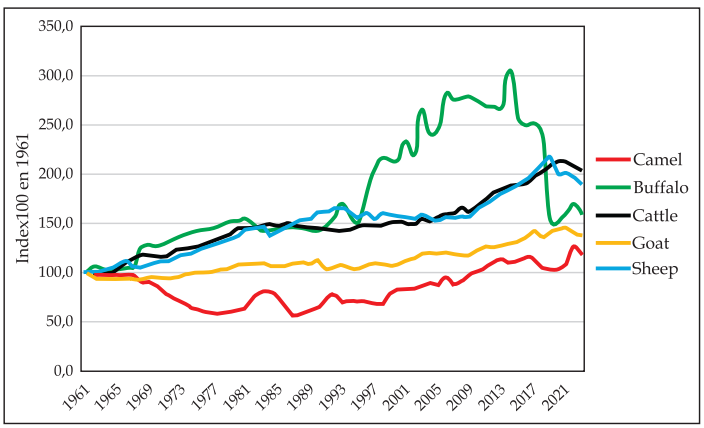

Fig 5. Relative changes in milk production around the MB from different dairy species (calculated from FAOstat, 2025).

the percentage of lactating camels seems to have decreased from 5.8% in 1961 to 1.5% nowadays. If the percentage of 18.2% (MB average) can be applied on average for all other countries (except in Europe where the number is approximately known), with a mean productivity of 1200-1600 L/lactation in Maghrebi camels (Abdalla *et al*, 2015), the potential of production around the MB can be estimated (Table 2).

On this base, the potential is more than 8 times the quantity declared in FAO database. However, if the mean milk productivity applied by FAO at world level (375 L/lactating camel/year) is retained, the total potential of production for the MB would be 45,893 tons of camel milk only. Compared to other dairy species, camel milk growth for the last 63 years remains lower (Fig 5).

Thus, it is difficult to know exactly the quantity of camel milk available in the region. According to the mode of calculation, important gaps are observed. Moreover, few parts of this milk are available on market due to the importance of self-consumption. Whatever the estimation, the quantity of camel milk around the MB is less than 1% (around 0.6%) of the total milk produced in the region. At world level, it is 0.42%. Obviously, high

Table 2. Declared and potential camel milk production according to the number of lactating camels in the different countries, declared (D) or estimated (E) and based of a milk productivity of 1200 L/lactation.

Country	Camel heads (2023)	Nb of lactating camels	Declared milk production (t)	Potential milk production (t)
Algeria	439134	97595(D)	15013.26	117114.00
Egypt	193667	18129 (E)	N/A	21754.82
Israel	5619	1022 (E)	N/A	1226.53
Jordan	13788	2483 (E)	N/A	2979.63
Lebanon	131	24 (E)	N/A	28.61
Libya	62852	10841 (D)	2215.43	13009.20
Morocco + WSahara*	175505	54643 (D)	9138.78	65571.60
Syria	33510	6533 (E)	N/A	7839.03
Tunisia	239042	3651 (D)	1105.2	4381.20
Turkiye	1197	219 (E)	N/A	262.95
France	900	30	N/A	36
Italy	300	0	N/A	0
Spain	4000	120	N/A	144
Greece	150	0	N/A	0
Balkan countries	100	0	N/A	0
TOTAL	1169895	195290	27473.01	234347.58

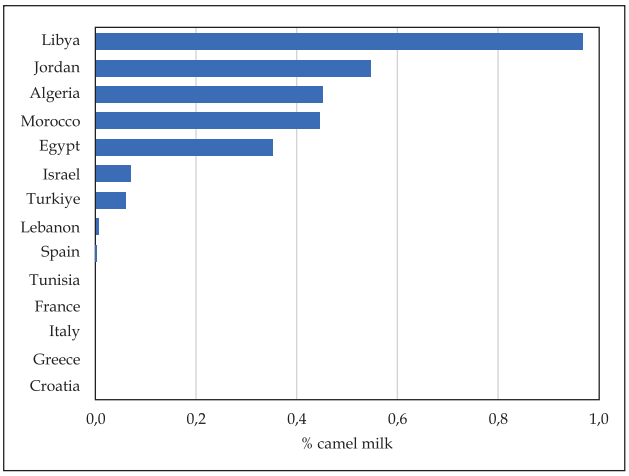

Fig 6. Percentages of camel milk in total milk produced around the MB (in %).

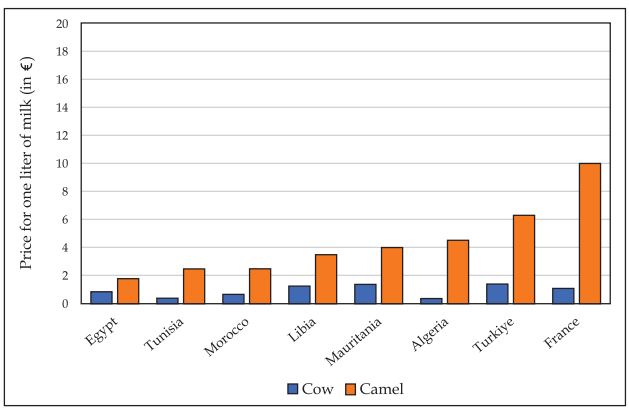

Fig 7. Differential prices between cow and camel milk in the MB.

differences occur between countries. In Libya only, the percentage was almost 1%, in Libya (Fig 6).

Moreover, within the countries, notably in North Africa, the proportion of camel milk in the total produced milk is more important in the desert part of the country. For example, in Saharan provinces of Morocco, it could reach 30% of the milk diet (Faye *et al*, 2014).

The challenges for the camel dairy development in the MB

The introduction of camel milk on market is a recent feature, in general all over the world as it was already underlined (Konuspayeva *et al*, 2022). Longtime, the camel milk was a part of the "gift economy" (Mauss, 1924), contributing to the "subsistence economy" (Polanyi, 1977) of the nomad people. The current mutation of the camel farming systems is not limited to some rich countries of the Middle East, but is involving also, most of the countries of the MB. Boosted by a growing urban demand in terms of quantity, quality and diversity of the dairy products, boosted also by the differential of price compared to cow milk based notably to the expected health effect of camel milk, the "commodification" of the camel milk is contributing to the emergence of true dairy camel sector at regional level. At the same time, theses mutations have an important impact on a certain "modernisation" of the camel farming systems (use of diet with high-concentration in energy and protein, low-mobility, machine milking, reproduction management, on-farm milk processing) and on the implementation of dairy plant processing exclusively or not camel milk. Although it was not strictly in a country of the MB, one of the pioneers regarding camel milk processing for the market was the dairy factory "Tiviski" in Mauritania (Abeiderrahmane, 1997). In Morocco, small-scale dairy plants were established in the southern part of the country. In Algeria, the dairy plant "Tedjane" started the marketing of

Fig 8. Truck of the dairy factory "Tedjane" at El-Oued (Algeria).

Fig 9. The small-scale dairy plant in the camel farm "La Camelerie" in France

fermented (laban) and pasteurized milk in 2018 (Fig 8). In Tunisia, several projects of camel dairy plants have started (Faye *et al,* 2014). In Türkiye, the first camel cheeses were proposed recently in dairy plant "Ovacik". In France, one first camel dairy farm with on-farm processing (pasteurised, milk, kefir, cheese) was implemented since 2021 (Fig 9). In Spain, the implementation of a milking parlour in the Goroy farm at Fuerteventura is started.

For answering to the growing demand in terms of quality and to be in accordance with the national regulations, an important effort was done to improve the hygienic conditions at milking, storage, transport and processing. In Europe, notably, the regulation regarding milk pasteurisation control must take in account the non-convenience of the use of alkaline phosphatase (ALP) as indicator of pasteurisation and the necessity to suggest other indicators such as lactoperoxidase or glutamyl transpeptidase (Lorenzen *et al,* 2011). Globally, the camel milk industry must propose a high variety of products adapted to the local eating habits, for example, types of cheese or fermented products.

The question of the price

One of the main constraints of camel milk development, is the price differential with the milk from other species, notably cow. Globally, camel milk price is between 2.5 to 20 times higher than cow milk (Fig 7)

Such differences could be justified by the higher production costs of camel milk production, due notably to the higher price of the animals and overall, to their lower productivity, especially around the MB where dairy cows are mainly high-yield breed such as Holstein or Montbeliard. Indeed, except in the eastern part of the MB (Türkiye, Syria, Lebanon, Israel, Palestine), the main camel breed is Maghrebi type, even if different phenotypes are described in the region (Chniter *et al,* 2013; Oulad-Belkhir *et al,* 2013; Boujenane *et al,* 2019). This type is among the relatively low-yield camels (Al-Hadrami and Faye, 2022) with a range of 1200-1800 L/lactation (Abdalla *et al,* 2015). Moreover, in most of the countries from the southern bank of MB, the areas of camel milk production are in desert wilayas far away from the consumption basins closed to the coastal areas. Such geographical configuration leads to adding costs linked to the transport of a highly perishable product. In Europe, the rare camel dairy farms face to a wide geographical demand at national or even European level, leading to similar constraints of transport.

In such conditions, camel milk will be never a substitution product of cow milk. Usually, the consumers accept to pay higher price on the believe that camel milk is beneficial for their health. In their survey on consumer acceptance and preference for camel milk, Profeta *et al* (2022) confirmed that expected or true health effect of camel milk is an important "buying factor", both for non-European

Fig 10. Pasteurised, fermented camel milk and camel cheese from the farm "La Camelerie" sold in the Festival of Janvry (France).

Fig 11. Pasteurised milk from the farm "Chamelait" in Tunisia sold at the conference "Milk, vector of development", Tunis (Tunisia).

and European consumers, even if these last appeared less completely convinced by the health claims. However, in Europe, the "exotic" image of the product is also a commercial argument. Moreover, the important community of Maghreb origin in France and Spain notably could represent a potential market for camel milk producers.

The market availability

As mentioned above, one of the constraints for the development of camel milk sector is the remoteness of production areas. Several stakeholders in the sector as well as policy makers regularly evoke the implementation of a spray-drying system to produce powder milk, rather for the international market than for the national one (Konuspayeva *et al,* 2022). However, the high cost of the necessary investment constitutes a brake for the implementation of one drying tower. Nowadays, only European market is supplied with camel milk powder produced mainly in United Arab Emirates that get European agreement to export (Nagy *et al,* 2014). The camel dairy farm implemented in Holland (Smits *et al,* 2023) is proposing also camel milk powder for the European market, but the quantity is limited. Camel milk powder is also available in on-line market managed by on-line platforms based overall in China and USA (Konuspayeva *et al,* 2022).

Pasteurised and fermented milk can be present in supermarket on few occasions (for example in Algeria), but in most of the cases, a small network of retailers is implemented in the production areas or out. A significant part of the products (milk, cheese, cosmetics) is sold during various events as fairs, festivals, open days, or conferences (Fig 10 & 11). But in all the cases, the distribution network of liquid milk comes from short circuits with a low number of middlemen. The market is for the moment too narrow to be integrated in the more important distribution networks implying cow milk.

Camel milk sector in the MB is just emerging in the economic landscape of the involved countries. Camel milk remains a "niche product", even if its recent growth was important. The high price of the product on the market cannot attribute to this product a competitive interest compared to cow milk, even in countries from the south bank of the MB where the camel population is important. Camel cannot be regarded as "the cow of the future" despite his advantages face to the current environmental challenges. However, the margin of development of the camel sector around the MB is not negligible and must be supported by more favourable regulations, notably in Europe. the different segments of the sector (production, processing, distribution) must be able to benefit from administrative and political support in the different concerned countries.

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CASEOUS LYMPHADENITIS SEPSIS (*Pseudotuberculosis*) IN A DROMEDARY CAMEL: A CASE REPORT

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ABSTRACT

A female dromedary dead adult camel in poor body condition was sent to the Central Veterinary Research Laboratory (CVRL) for a proper necropsy. It was sick for a long time. No external lesions were observed but all external and internal lymph nodes were swollen containing multiple abscesses. All internal organs except kidneys and heart were infected with multiple abscesses of different size from which *C. pseudotuberculosis* serovar1 (ovine/caprine), was isolated.

Key words: Camel, caseous, lymphadenitis, pseudotuberculosis

Caseous lymphadenitis (CLA) or *pseudotuberculosis* is one of the most important bacterial infectious diseases in livestock. It is caused by a Gram-positive coccus-like bacteria named *Corynebacterium* (C.) *pseudotuberculosis*. The pathogen affects sheep and goats worldwide, produces an ulcerative lymphangitis in cattle and an endemic disease in horses in California, named pigeon fever (Promed, 2007). It is widespread in Old World camels (OWCs) and the pathogen has also been isolated from abscesses of New World camels (NWCs). Extensive investigations about this disease have been published over the last decades and a review was summarised by Wernery *et al* (2014) and (2016). We report here about a severe caseous lymphadenitis (CLA) case of a dromedary female adult camel sent to CVRL for necropsy.

Materials and Methods

An adult non-pregnant female dromedary camel weighing 360 kg in poor condition was necropsied at CVRL. It died after a long illness during which its body condition had deteriorated. During adspection, no external lesions were observed, but all external lymph nodes were enlarged, mainly the prescapular, popliteus and mammary lymph nodes. A severe soft swelling of the right carpal joint was also observed. When opening the lymph nodes, multiple abscesses containing creamy-coloured pus were observed. The right carpal joint was also filled with creamy pus. During necropsy all organs except kidneys and heart displayed multiple abscesses of different size. From each organ, abscess swabs were taken and streaked on 3% sheep blood agar. The agar plates were incubated for 48 h at 37°C. A lung swab taken from the cavern was stained after Gram and examined microscopically at a magnification of 100x with oil. Pieces of tissue from all organs were submerged in 40% formalin and processed and slides stained with haemotoxlin/eosin (HE) and examined microscopically.

Results

The lesions caused by *C.pseudotuberculosis* are presented in different pictures.

Discussion

C.pseudotuberculosis causes caseous lymphadenitis (CLA) in many different animal species. The disease is characterised by abscessation of one or more superficial lymph nodes and like in this case may also cause severe alterations in internal organs including mammary gland (Wernery and Kinne, 2016). The infection is spread via ingestion, inhalation or directly through wounds. In this case no external lesions were observed. Affected camels often concurrently suffer a severe tick infestation (*Hyalomma dromedarii*) from which *C.pseudotuberculosis* is often isolated. Mucous membranes of the oral cavity might be also damaged by acacia thorns

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and or by dry and hard stems of desert plants or ingested hay. Following the entry through the skin or mucous membranes, the pathogen is phagocytised predominantly by leucocytes and transported mainly by lymph to the predeliction sites which are nearby lymph nodes, where it causes abscesses of different size. The virulence of *C.pseudotuberculosis* is attributed to a major exotoxin, phospholipase D (PLD) which

Fig 1. Abscesses in the right carpal joint extending dorsal along the tendons of the deep digital flexors and *Mn. Interossei.*

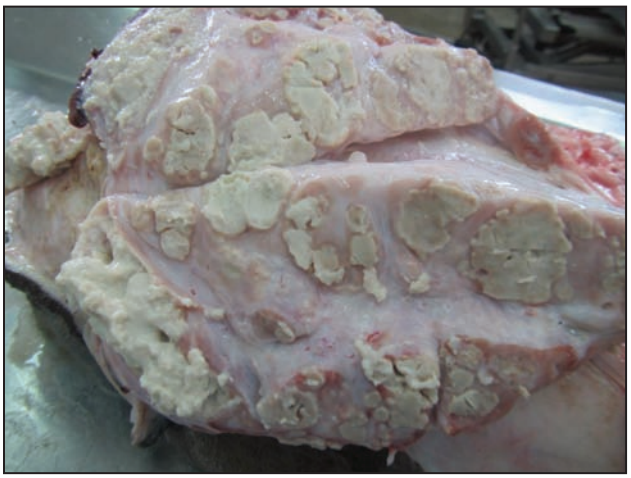

Fig 2. Multiple abscesses in the udder lymph node (*L. nn. inguinales superficiales, L. nn. mammarii*).

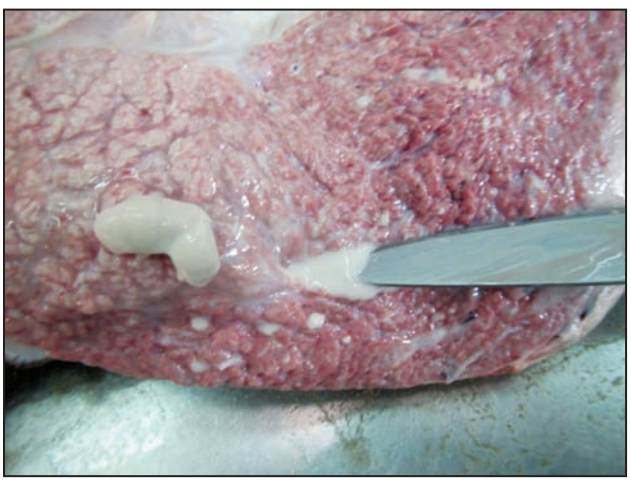

Fig 3. Micro abscesses in the left hind udder quarter.

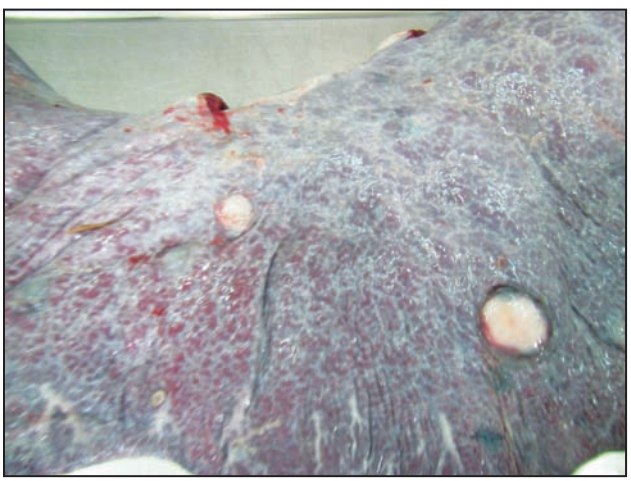

Fig 4. Two small abscesses in the spleen.

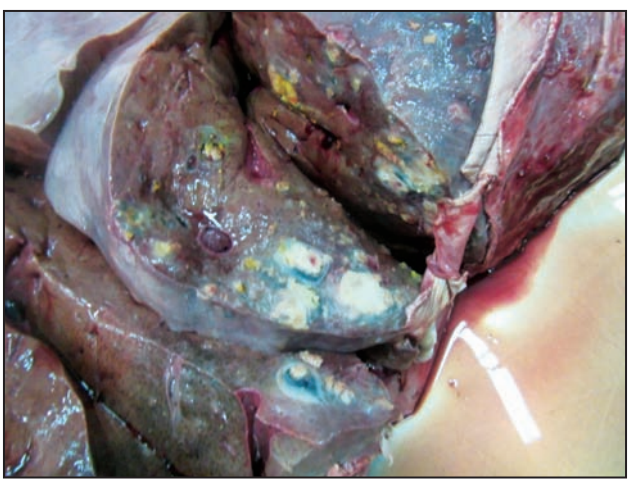

Fig 5. Multiple abscess formation of different size in the liver.

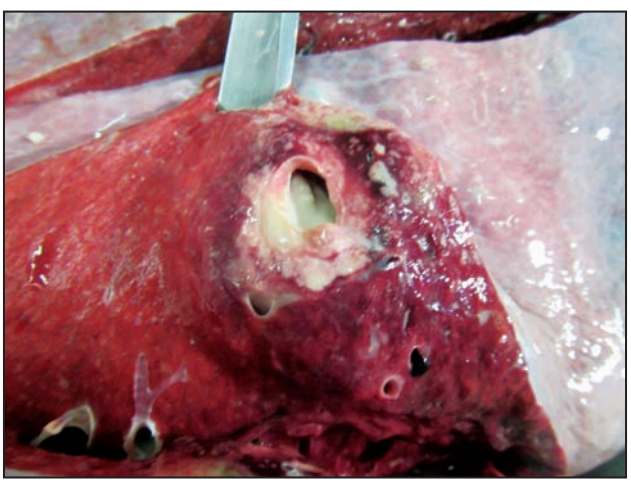

Fig 6. Golf ball size abscess opened showing cavernous appearance containing cream coloured pus.

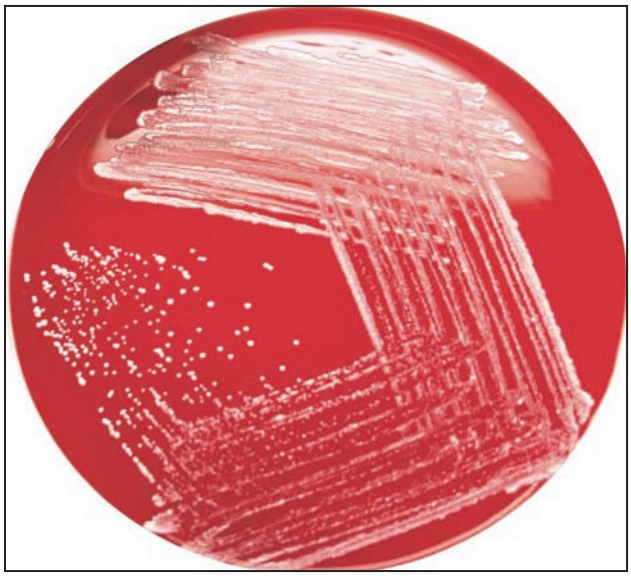

Fig 7. *Corynebacterium pseudotuberculosis* colonies on 3% sheep blood agar grown after 48hrs incubation at 37°C as small white, dry colonies surrounded by a narrow zone of haemolysis.

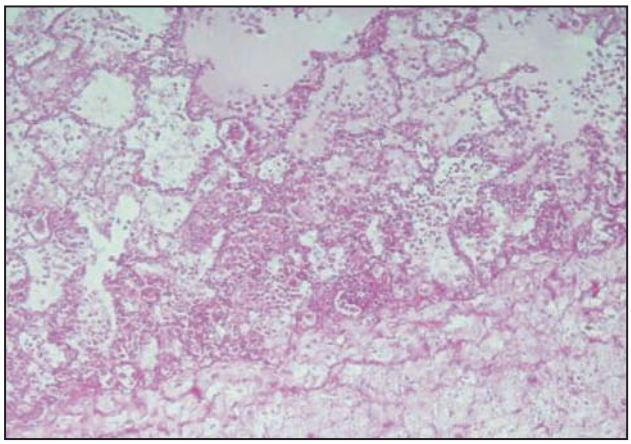

Fig 9. Massive alveolar and marked intralobular oedema of the lung with some fibrin and central necrotic masses.

increases vascular permeability and also facilitates dissemination of the pathogen into neighbouring lymph nodes where it inhibits chemotaxis and death of neutrophils as well as inactivation of complement (Markey *et al*, 2013). Often the immune system of the infected animals is overwhelmed by the infection and the pathogen enters different organs like in this case. In lungs it not only produces abscesses but often caverns. Two bio types are known to infect camels (Berlin, 2015), biotype 1 (biotype ovine/caprine) and biotype 2 (biotype bovine/equine). Biotype 1 was isolated from this case using the nitrate reduction test (Berlin, 2015).

Although Corynebacteria are very sensitive to penicillin, tetracyclines and cephalosporins treatment of chronic CLA is unrewarding. Multiple abscesses

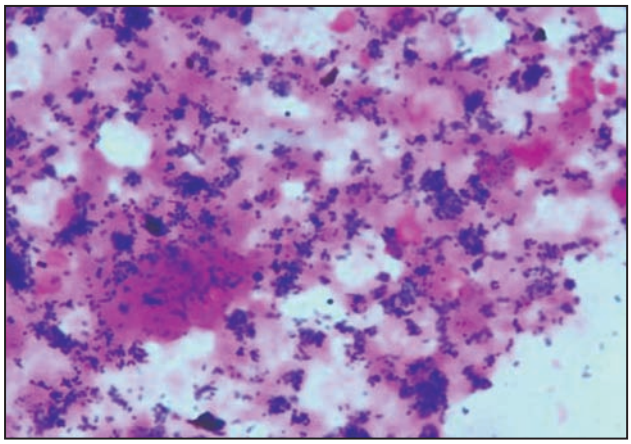

Fig 8. *Corynebacterium pseudotuberculosis* bacteria from a lung abscess smear, stained with Gram 100x oil.

with fibrous capsule and pus in the abscesses prevents the medication from reaching the bacteria. Vaccines against CLA for sheep and goats are available, but not for camelids. However, several vaccine candidates have been tried especially in NWCs with different success (Wernery, 2015). Berlin *et al* (2015) used only the exotoxin PLD from non-formalin inactivated culture supernatant containing no *C.pseudotuberculosis* bacteria or any bacterial cell wall protein. The mixture of both CLA biotypes 1 and 2 containing 750 mg PLD per dromedary gave a complete protection against a challenge dose containing 4.0 x 10^3 cfu/ml of an ovine/caprine biotype. Sero conversion was tested with an indirect CVRL in house ELISA using PLD as antigen and protein A as conjugate.

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VEHICLE-CAMEL COLLISIONS IN SAUDI ARABIA: APPLICATION OF SINGLE AND MULTI-STAGE DEEP LEARNING OBJECT DETECTORS

Vehicle-camel collision is a persistent issue in countries where population of camels is high such as Saudi Arabia. The purpose of the research is to introduce a new solution to eliminate this issue. Previous solutions, such as fencing the sides of the roads, designing better camel warning signs and fining camel owners when camels cross high traffic roads, are either expensive, ineffective, or hard to implement. Therefore, in this work, we harness the power of deep learning to tackle this problem. In particular, we use state-of-the-art deep learning object detectors to detect camels on roads with high accuracy. Results show that all implemented models were capable of detecting camels on or near roads. Moreover, the single-stage detector Yolo v3 was found to be the most accurate and is as fast as its successor Yolo v4. Findings of this work helped select the deep learning model needed for a reliable and automatic vehicle-camel collision avoidance system.

(Source: Saleh Alghamdi, Abdullah Algethami, Ting Tan. Vehicle-camel collisions in Saudi Arabia: Application of single and multi-stage deep learning object detectors. Ain Shams Engineering Journal, Volume 15, Issue 1,2024,102328,ISSN 2090-4479, https://doi.org/10.1016/j.asej.2023.102328)

LAUDATIO FOR PROFESSOR ROLF K SCHUSTER

Farewell Party for Prof. Schuster at CVRL

Prof. Rolf K Schuster retires at the age of 68 years as the head of the Parasitology Department at CVRL on 31-01-025. Prof. Schuster, who has studied in Moscow, Russia Veterinary Science and became Professor of Parasitology at the Free University in Berlin, Germany has worked as a veterinarian in many different countries including Mongolia, South Africa, Malawi, where he gained tremendous knowledge about parasites in different animal species worldwide, which culminated in around 100 publications, 20 alone at CVRL, where he worked for 22 years. His urge for knowledge and scientific interest for parasites even in bees, wasps and shrimps has catapulted veterinary parasitology in the United Arab Emirates to a new level. He will retire in China and as a keen angler we will read more about parasites in Chinese fish. CVRL and especially his team at CVRL wishes him and family good health and a great start into his new life.

U. Wernery, J. Kinne, Saritha Sivakumar, Sweena Liddle, Vineetha Gopinath

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THE IMMUNOPHENOTYPE OF BLOOD MONONUCLEAR CELLS IN THREE AGE GROUPS OF DROMEDARY CAMELS (*Camelus dromedarius*)

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ABSTRACT

Age related changes in the immune system were described for different humoral and cellular immune components in man and animal. Studies on the development of the cellular immune system in camels are limited. Therefore, the present study compared the three age groups of camels regarding the immunophenotype of mononuclear cells in their blood. Thirty-four dromedary camels were divided, based on their age, into three groups (G) with camels in G1 aged 3 - 11 month, camels in G2 aged 2 - 5 years, and G3 camels aged 6 - 10 years. The immunophenotype of mononuclear cells was analysed by flow cytometry. The results revealed higher percentage of lymphocytes in G1 and G2 than G3, while lymphocyte absolute numbers were only higher in G1 than the other two groups. Within lymphocytes, the absolute numbers of WC1+ T cells and B cells were highest in G1 compared to the other two groups, while the absolute numbers of CD4+ T cells did not show significant differences between the groups. In addition, the reduced abundance of CD11ahigh and CD44high lymphocytes together with the reduced expression of CD9 on lymphocytes and MHC II on monocytes indicate the reduced maturity of the camel immune system during the first year of life. In conclusion, the present study identified significant age-related changes in the immunophenotype of mononuclear cells in camel blood. The changes are characterised by a decrease in the number of lymphocyte, gd T cells, and B cells. In addition, age was associated with an expansion in activated lymphocytes and monocytes in camel blood.

Key words: Age, dromedary camel, flow cytometry, lymphocytes, monocytes

Blood mononuclear cells, including cells from the lymphoid (lymphocytes) and myeloid (monocytes) lineage with key roles in innate and adaptive immune functions, are easily accessible tool for studying the immune system. Immunophenotyping of mononuclear cells by flow cytometry has been intensively used for the identification of changes in the distribution of cell subsets in different physiological and pathological conditions (Johnson *et al,* 2022; Li *et al,* 2022; Heubeck *et al,* 2023).

Expressed on all leukocytes, CD11a dimerizes with CD18 to form the adhesion molecule lymphocyte function antigen-1 (LFA-1) (Roos and Law, 2001; van de Vijver *et al,* 2012). The lymphocyte homing receptor CD44 plays an essential role in lymphocyte adhesion and migration (Schumann *et al,* 2015). Both CD11a and CD44 are prominent activation markers of lymphocytes (McDermott and Varga 2011; Schumann *et al,* 2015). The tetraspanin CD9 is widely expressed molecule (expressed by several lymphoid and myeloid cells as well as by endothelial cells). In leukocytes, CD9 has been found involved in many cellular activities, including proliferation, activation, adhesion and migration (Reyes *et al,* 2018). Major histocompatibility (MHC) class II molecules are expressed on antigen presenting cells, including monocytes and B cells in blood as well as macrophages and dendritic cells in tissue (Holling *et al,* 2004; Zheng *et al,* 2022). MHC II are antigen receptors that present peptide antigens to T helper cells (Abeles *et al,* 2012).

Age-related changes in the phenotype and function of several immune cells were reported for several species (Hussein *et al,* 1992; Hulstaert *et al,* 1994; Ayoub and Yang 1996; Yan *et al,* 2010; Lin *et al,* 2016). Compared to other livestock, studies on the cellular immune system of camel are still very limited (Zidan *et al,* 2000a; Zidan *et al,* 2000b). The present study compared the distribution and activation status of cellular subsets within blood mononuclear cells in three age groups of camels.

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Materials and Methods

2.1 Animals and blood sampling

Thirty-four dromedary camels (*Camelus dromedarius*) divided into three age groups were involved in the current study. The first group (G1) contained 10 camels aged between 3 and 11 month (mean ± SEM: 7.6 ± 0.7 month); the age group 2 (G2) contained 5 camels aged between 2 and 5 years (3.2 ± 0.5 year); the age group 3 (G3) contained 19 camels aged between 6 and 10 years (7.8 ± 0.3 years). The camels were kept in different private farms in Al-Ahsa region in Saudi Arabia. Blood was obtained by venipuncture of the vena jugularis externa into vacutainer tubes containing EDTA (Becton Dickinson, Heidelberg, Germany).

2.2 Separation of whole leukocytes

Separation of whole camel leukocytes was performed by hypotonic lysis of erythrocytes. For this, 2 mL blood was incubated in 5 mL distilled water for 20 sec and 5 mL of 2x PBS was added to restore tonicity. After centrifugation at 1000 xg for 10 min, the erythrolysis was repeated twice until complete removal of red blood cells. Separated cells were finally suspended in PBS containing bovine serum albumin at 2 x 10^6 cells/ml.

2.3 Cell labeling and flow cytometry

Camel leukocytes (2 x 10^5 / well of 96 well plate) were incubated with monoclonal antibodies specific for CD4, WC1, CD9, CD11a, CD44, and MHC-II molecules in PBS containing bovine serum albumin (Hussen, 2021). After 15 minutes incubation at 4°C, cells labelled with primary antibodies were washed twice and incubated with secondary antibodies to mouse IgG1, IgG2a, and IgM. After final wash, the cells were analysed on the flow cytometer (Accuri C6; BD).

Statistical Analyses

Statistical analysis was performed with Prism (GraphPad). Results are presented as means ± S.E. of the mean (SEM). Differences between means were tested with one-factorial analysis of variance (ANOVA) and Bonferroni's correction for normally distributed data. Results were considered significant at a p-value of less than 0.05.

Results and Discussion

The percentage of lymphocytes (Fig 1A) was significantly ($p < 0.05$) higher in G1 (33.1 ± 1.4 % of leukocytes) and G2 (24.2 ± 1.6 % of leukocytes) than G3 (19.3 ± 1.5 % of leukocytes), while lymphocyte absolute numbers (Fig 1B) were only elevated ($p < 0.05$) in G1 (1690 ± 199 cell/µL blood) than G 2 (949 ± 153 cell/µL blood) and G 3 (1116 ± 97 cell/µL blood). Neither the percentages nor the absolute numbers of monocytes differed ($p > 0.05$) between the three groups (Fig 1A and B). The observed higher percentages and numbers of lymphocytes in the younger age group is in line with the physiological age-related lymphocytosis reported in camels (Hussein *et al,* 1992; Gaashan *et al,* 2020). In a previous study, highest lymphocyte numbers in one-month aged camel calves followed by age-associated decrease was reported (Hussein *et al,* 1992).

The estimation of the abundance of subpopulations within camel lymphocytes revealed significant age-related changes. The percentage of CD4+ T cells was higher in G2 (18.1 ± 3.6 % of lymphocytes) and G3 (19.1 ± 1.2 % of lymphocytes) than G1 (11.8 ± 0.8 % of lymphocytes), the difference was, however, only significant ($p < 0.05$) between G1 and G3 (Fig 2A). In contrast to this, the percentage of WC1+ T cells was significantly ($p < 0.05$) higher in G1 (22.7 ± 1.8 % of lymphocytes) and G2 (9.6 ± 2.6 % of lymphocytes) than G3 (3.9 ± 0.4 % of lymphocytes). The fraction of B cells did not show significant differences between the three groups. The absolute numbers of WC1+ T cells were highest in G1 (383 ± 56 cell/µL) compared to the G2 (97 ± 30 cell/µL) and G3 (41 ± 5 cell/µL), while the absolute numbers of CD4+ T cells did not show significant differences between the groups. For B cells absolute number, a significantly higher number was found in the G1 (426 ± 54 cell/µL) than G2 (254 ± 69 cell/µL) and G3 (227 ± 30 cell/µL).

The observed lymphocyte composition confirms the previously reported dominance of γδ T cells over other blood lymphocytes in camel calves during the first year of life (Hussen, 2018; Hussen and Schuberth, 2020). The results also indicated rapid change in γδ T cell frequency with a rapid decrease of their percentages and numbers in the G2 camels aged 2-5 years. Age-related changes in B cell distribution and populations were described in different species (Blanco *et al,* 2018). Early life increase in B cells and subsequent decrease in B cell numbers was described previously for human B cells (Rodriguez-Zhurbenko *et al,* 2019).

The percentage of $CD11a^{high}$ lymphocytes (Fig 3A) was significantly higher in G3 (25.4 ± 2.6% of lymphocytes) than G1 (10.1 ± 1.1% of lymphocytes) and G2 (14.2 ± 1.0% of lymphocytes). For the fraction of $CD44a^{high}$ lymphocytes (Fig 3A),

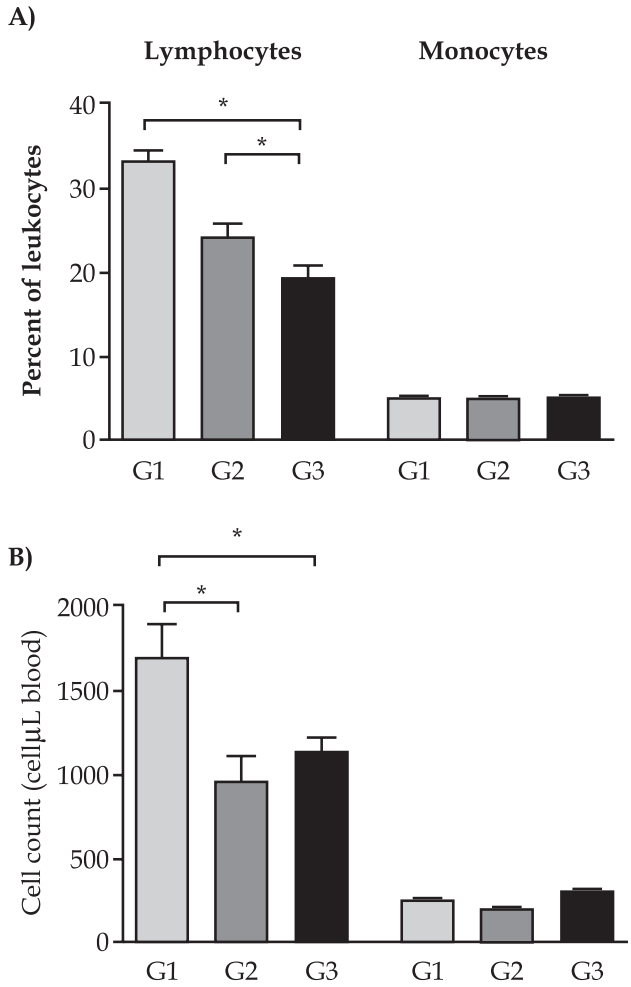

Fig 1. Impact of age on the frequency of camel mononuclear cells. A) The percentage of lymphocytes and monocytes were calculated after flow cytometric identification of the cells based on their forward and side scatter properties. B) The absolute numbers of lymphocytes and monocytes were calculated by multiplication of their percentages by the absolute number of leukocytes counted by light microscopy and Turk solution. * indicates significant ($p < 0.05$; One-Way ANOVA).

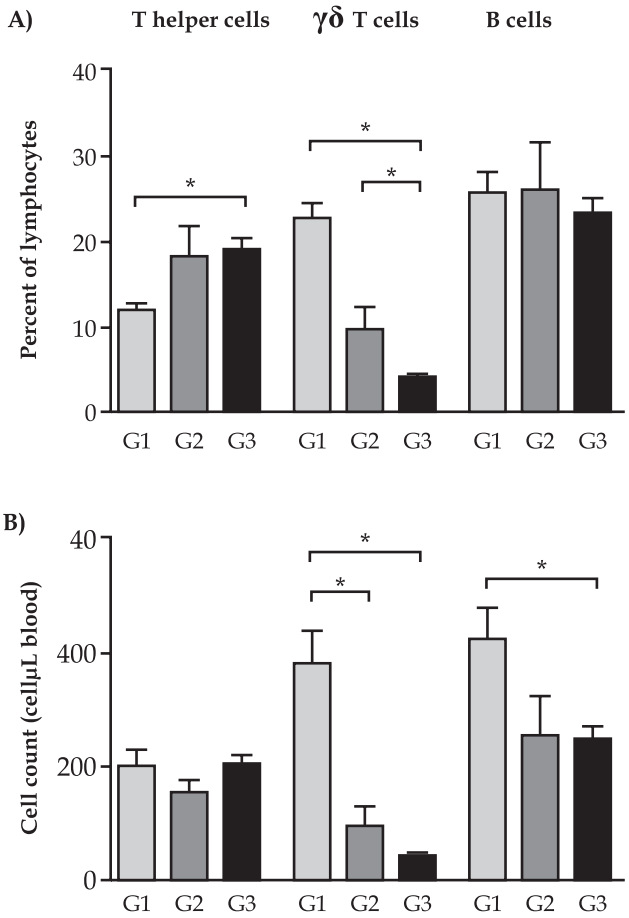

Fig 2. Age-related changes in the frequency of lymphocyte subsets in blood. A) Percentage of helper T cells, gd T cells and B cells were calculated after labeling leukocytes with antibodies to the markers CD4, WC1, and MHC II, respectively. B) The absolute numbers of cell subsets were calculated by multiplication of their percentages by the absolute number of lymphocytes. * indicates significant ($p < 0.05$; One-Way ANOVA).

a higher percentage was observed in G2 (29.9 ± 4.9% of lymphocytes) and G3 (31.2 ± 2.8% of lymphocytes) than in G1 (18.4 ± 1.9% of lymphocytes). The expression density (mean fluorescence intensity; MFI) of CD9 was higher on lymphocytes from G2 (4885 ± 607) and G3 (4536 ± 664) than G1 (2980 ± 320). The difference was however, only significant between G1 and G2 (Fig 3B).

In addition to many other cell markers, CD11a (also known as lymphocyte activator antigen 1) and CD44 are two activation marker of lymphocytes with effector lymphocytes expressing high levels of these molecules (Azeredo *et al,* 2006; Schumann *et al,* 2015). The reduced abundance of lymphocytes expressing high levels of both molecules in the G1 confirms the reduced maturity of the camel immune system during the first year of life. This also confirmed by the reduced abundance of the tetraspanin CD9, an other activation marker highly expressed on activated lymphocytes (Reyes *et al,* 2018). In addition, the early increase in the frequency of $CD44^{high}$ lymphocytes (in G2) than $CD11^{high}$ lymphocytes (in G3) indicates that these molecules identify different cell populations within lymphocytes.

Major histocompatibility complex (MCH) class II molecules are antigen receptors responsible for presenting antigens to the adaptive immune system (Holling *et al,* 2004). Their expression is also considered indicative of monocyte activation status (Hussen *et al,* 2013). In the present study, the

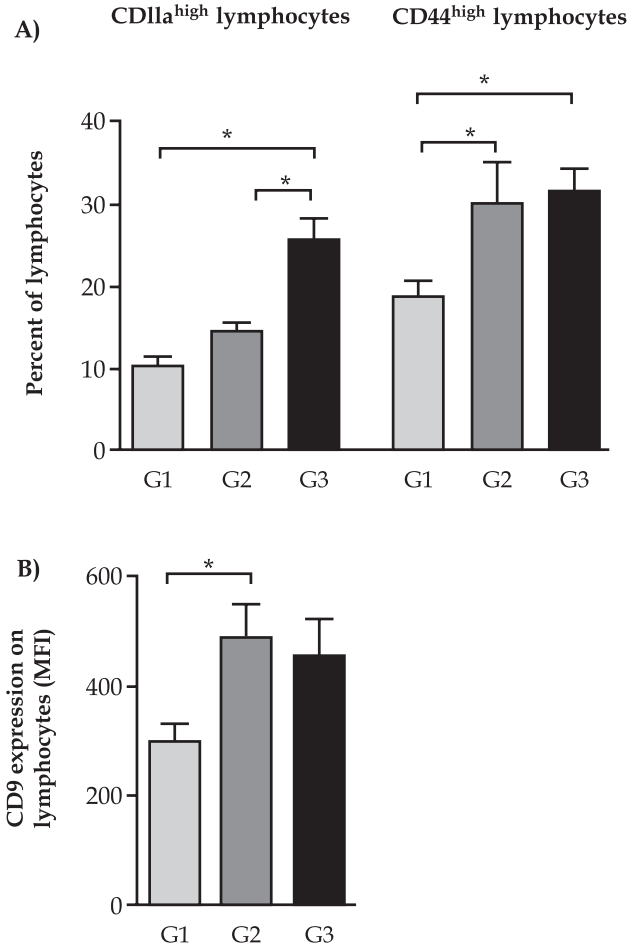

Fig 3. Age-related changes in the percentage of activated lymphocytes. A) Percentage of CD11a^{high} and CD44^{high} lymphocytes were calculated after labeling leukocytes with antibodies to the activation markers CD11a and CD44. B) The abundance of CD9 molecules on lymphocytes. Leukocytes were labeled with antibodies to CD9 molecules and analysed by flow cytometry. The abundance of CD9 molecules on lymphocytes was calculated as mean fluorescence intensity (MFI) and presented for the three groups. * indicates significant ($p < 0.05$; One-Way ANOVA).

abundance (MFI) of MHC II was higher on monocytes from G2 (7529 ± 520) and G3 (6899 ± 395) than G1 (5314 ± 589). However, the difference was only significant between G2 and G1 (Fig 4). These data also supports the reduced maturity of monocytes in camel calves during the first life of age with improved maturity starting with the second year of age.

Ethical approval

This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the Ethics Committee of King Faisal University, Saudi Arabia (KFU-REC-2024-JUN-ETHICS1843).

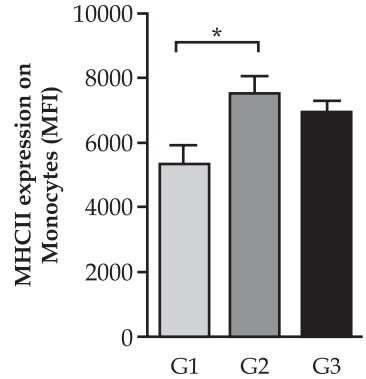

Fig 4. Abundance of MHC II molecules on monocytes. Leukocytes were labeled with antibodies to MHC II molecules and analysed by flow cytometry. The abundance of MHC II molecules on monocytes was calculated as mean fluorescence intensity (MFI) and presented for the three groups. * indicates significant ($p < 0.05$; One-Way ANOVA).

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SEASONALITY OF AQUAPORIN 5 IMMUNOREACTIVITY IN THE DROMEDARY CAMEL'S DUCTUS EPIDIDYMIS

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ABSTRACT

Intrinsic membrane proteins designated aquaporins promote the selective movement of water or other small, uncharged molecules down the osmotic gradient. The objective of this research was to use a light microscope to investigate the seasonal variations in the immunoreactivity of Aquaporin 5 (AQP-5) in the ductus epididymis of the local breed of Saudi dromedary camel. Samples were obtained from the head, body, and tail (caput, corpus, and cauda) of the ductus epididymis and processed using general histology and immunohistochemical methods. General histology and immunohistochemistry techniques were used to process samples taken from the head, body, and tail of the ductus epididymis. AQP-5 antibodies exhibited distinct and variable responses on the caput, corpus, and cauda of the ductus epididymis of the Saudi Arabian camels in both rutting and non-rutting seasons. The distribution of AQP-5 was strongly expressed in the non-rutting seasons. At the beginning of the rutting season, AQP-5 showed a strong response. However, in the rutting season in January, the excretion showed mild to moderate response in the caput, corpus, and cauda ductus epididymis. According to the present results, AQP-5 activity in Saudi dromedary male camels may play an essential role in fertility during rutting and non-rutting seasons at different levels.

Key words: Aquaporin 5, camel, epididymis, immunohistochemistry

The dromedary camels can live in various dry and semi-arid conditions due to their great environmental adaptation (Merkt *et al,* 1990; Tibary and El Allali, 2020). Seasonality in reproduction has been noted in various species, including male dromedary camels (Al-Bulushi *et al,* 2019). Camels have a longer breeding season than previously thought; dromedary camels are thought to breed seasonally (Eiwishy, 1987). Male camels breed periodically, and a noticeable increase in sexual activity (the rut) marks the start of the mating season (Marai *et al,* 2009). Nevertheless, at any time of year, by mating with an oestrous female, the male can still fertilise the oocyte (Marai *et al,* 2009).

The epididymis is a crucial reproductive organ that regulates sperm concentration and maturity, as well as storage, protection, motility, and fertilising capability (Flannigan and Goldstein, 2018; James *et al,* 2020).

The epididymis embryonic origin is the mesonephric ducts, a part of the intermediate mesoderm (McGeady *et al,* 2017). The epididymis is separated macroscopically into a head, body, and tail. Surrounding it is a dense, irregular connective tissue layer called the tunica albuginea, thick and coated in the visceral layer of the tunica vaginalis. A few smooth muscle cells can be seen sporadically throughout the dense connective tissue of the tunica albuginea in stallions (Eurell and Frappier, 2006).

The membrane protein channels known as aquaporins (AQPs) are essential for the quick movement of water through epithelium (An and Wang, 2016). Numerous human and other species tissues contain AQPs, which play a role in the bidirectional transmembrane transport of water and other tiny solutes. They regulate the fluid flow in tissues and cells, particularly the male reproductive organs, by facilitating the rapid passive passage of water (Verkman and Mitra, 2000; Kannan *et al,* 2020; Agre *et al,* 2002). From AQP0 to AQP12, in mammals, there are thirteen different AQP isoforms (Carrageta *et al,* 2020).

The morphology of the male camel epididymis was examined by numerous researchers, including Tingari and Moniem (1979); Alkafafy *et al* (2011); Purohit *et al* (2022); Saini *et al* (2023). There is a

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little investigation in the literature on the seasonal histological changes in the ductus epididymis, for example; that was described by Ibrahim and Singh (2014); Zayed *et al* (2012); Abdel-Maksoud *et al* (2019); Sary *et al* (2022;). Research on the immunoreactivity of aquaporins in dromedary camel is scarce (Al-Thnaian 2023 a and b, Marwa-babiker, 2024; Abdelhay, 2024; Elseory, 2024 a, b). The purpose of this research was to use histological and immunohistochemical methods to identify AQP-5 in the ductus epididymis.

Materials and Methods

Ethical approval: Each stage of the animal sample procedure was done according to the Saudi Arabian Ministry of Environment, Water, and Agriculture's ethical guidelines and procedures for slaughtering animals. The animal sampling was authorised by the King Faisal University Ethics Committee (KFU-REC-2023-NOV-ETHICS1545). In this study, twelve (12) Saudi Arabian male camels of the native breed (*Camelus dromedarius*) that were between the ages of four and eight years old and in good condition were used. The Al-Omran slaughterhouse in Al-Ahsa, Saudi Arabia, was the location of the animal slaughter. Six animals were in the December–February rutting season and six in the May- August non-rutting season.

The specimens were taken from the epididymal head, body, and tail (the caput, corpus, and cauda regions). They were used immediately after animal slaughter and fixed with 10% neutral formalin. Then, specimens were dehydrated in an ascending series of ethanol cleared in xylene and embedded in paraffin wax. A rotatory microtome was used for cutting 5µm thick tissue sections. The sections were stained with Hematoxylin and Eosin (H&E) according to Culling (1974) and Suvarna *et al* (2019).

Each animal group was dewaxed in xylene and rehydrated in decreasing amounts of ethyl alcohol for the immunohistochemical analysis. PBS (phosphate-buffered saline) was used to clean the sections. Tissue sections were rehydrated in PBS after being deparaffinised in xylene and ethanol alcohol. For fifteen minutes, antigen retrieval was carried out in a microwave oven using 0.01M PBS (pH 7.4). The parts were then allowed to cool at room temperature before being cleaned in PBS again. Endogenous peroxidase was blocked by using 3% hydrogen peroxide for 30 min. After washing in PBS three times, the goat serum (10%) was used for 20 minutes to avoid non-specific reactions. Then, the primary antibody, polyclonal rabbit anti-AQP5 was applied (Abcam, Cambridge, UK dilution 1:200) according to the manufacturer's instructions. The sections were then kept in a moist chamber for overnight. Sections were treated with avidin-HRP third antibodies and secondary antibodies labeled with biotin. To find the positive staining DAB was utilised. Section counter-staining was done using hematoxylin stain. Negative control sections have the same procedure except for skipping the primary antibody (Suvarna *et al,* 2019).

Results and Discussion

The epididymis was found divided macroscopically into a caput, corpus, and cauda (Figs 1 and 2). The ductus epididymis was highly convoluted, it had circular smooth muscle fibres and a tiny amount of loose connective tissue around it. It was lined by a high-pseudostratified columnar epithelium with stereocilia (Figs 1 and 2). The spermatozoa were present in the lumen of the different parts of the epididymis in both rutting and non-rutting seasons (Figs 1 and 2).

AQP-5 antibodies in Saudi dromedary camels during rutting and non-rutting seasons exhibited different levels of response on the caput, corpus, and cauda of the epididymis (Figs 1 and 2, Table 1).

The immune reactivity of AQP-5 at the beginning of the rutting season (October) strong expressions were observed in the caput, corpus, and cauda of the epididymis in the lining epithelium and muscular coat and connective tissue (Fig 1, a, b and c, respectively). However, in January there was mild immunological expression in the caput (Fig 1 d). The

Table 1. AQP-5 seasonal immunoreactivity in the epididymis of Saudi Arabian dromedary camels.

Season	Ca			Co			Cu		
	LE	MC	CT	LE	MC	CT	LE	MC	CT
Beginning of Rutting	+++	+++	+++	+++	+++	+++	+++	+++	+++
Rutting	+	+	+	++	++	++	++	++	++
Beginning of non-rutting	+++	++	++	+++	++	++	+++	++	++
Non-rutting	+++	++	+++	+++	++	+++	+	+	+

Abbreviations: + mild, ++ moderate, +++strong, Ca caput, Co corpus, Cu cauda, LE lining epithelium, MC muscular coat, CT connective tissue.

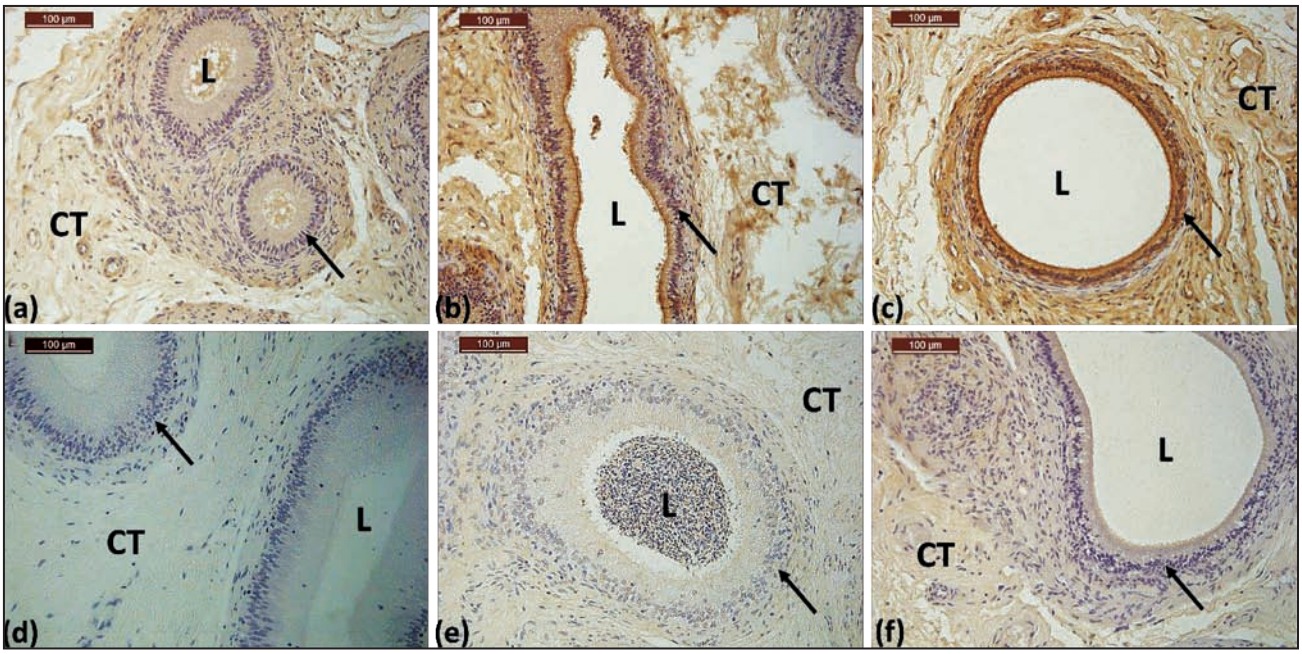

Fig 1. (a), (b) and (c): the photomicrographs of the caput corpus and cauda of the ductus epididymis of Saudi Arabian dromedary camel at the beginning of the rutting season in October showing a strong immune response in the lining epithelium (arrow), 20X,20X,20X, respectively. (d), (e), and (f): the photomicrographs of the caput, corpus, and cauda of the ductus epididymis of Saudi Arabian dromedary camel in the rutting season in January showing mild (caput) to moderate (corpus and cauda) immunoreactivity of AQP-5. Epithelium and stereocilia (arrows) and smooth muscle (S). Spermatozoa in the lumen (L), lining epithelium (arrows), the connective tissue (CT). 20X, 20X, 20X, respectively.

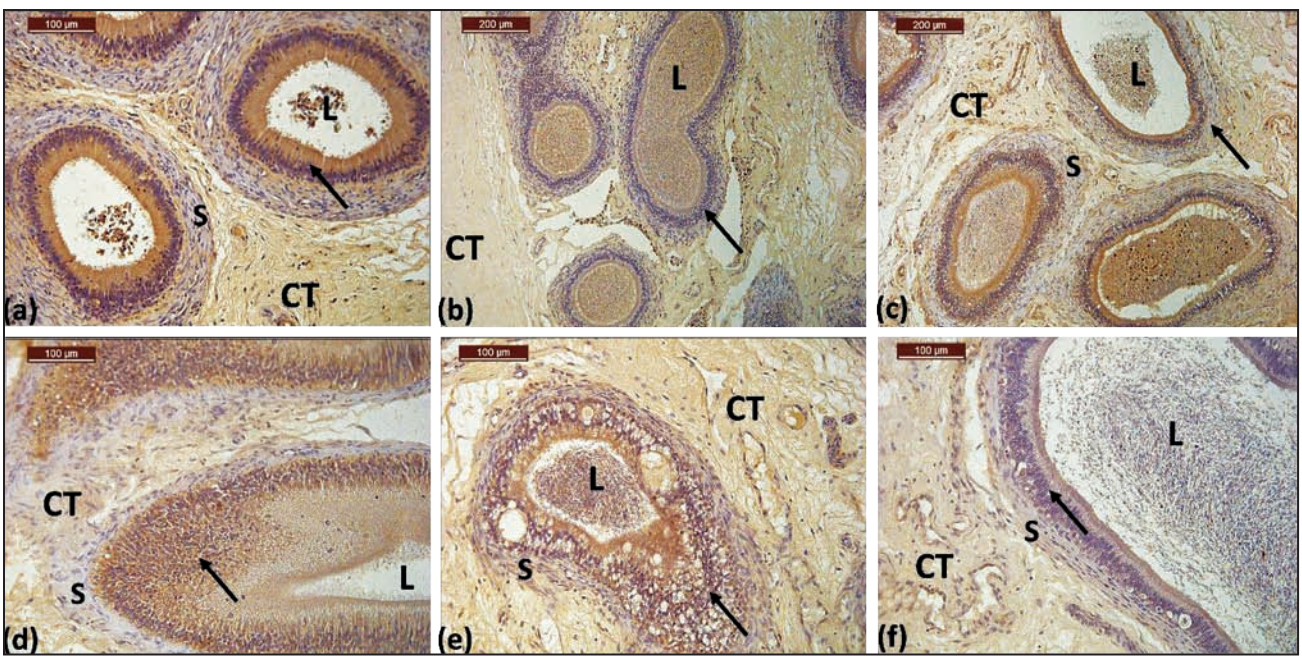

Fig 2. (a), (b), and (c): the photomicrographs showing the caput, corpus, and cauda of the ductus epididymis of Saudi Arabian dromedary camel in the beginning of non-rutting season (May), the lining epithelium (arrows), smooth muscle (S), connective tissue (CT) and lumen (L). 20X, 10X, 10X, respectively. (d), (e) and (f): the photomicrographs showing the caput, corpus, and cauda of epididymis immunoreactivity of AQP-5 in the non-rutting season (August). Epithelium and stereocilia in the caput, corpus, and cauda (arrows), Smooth muscle (S), Connective tissue (CT) Lumen (L). 20X, 20X, 20X, respectively.

corpus and cauda of epididymis showed moderate expression of AQP-5 in the spermatozoa in the lumen, the lining epithelium, and the connective tissue (Fig 1 e and f).

The immunoreactivity of AQP-5 at the beginning of the non-rutting season (May) in the Saudi dromedary camel's ductus epididymis caput, corpus, and cauda displayed a strong response

to AQP-5 in the epithelium and stereocilia. The muscular coat and connective tissue had a moderate response (Fig 2 a, b, and c). In addition, in August the caput and corpus displayed a significantly strong immunological expression of AQP-5 in the lining epithelium and connective tissue, however, the muscular coat had a moderate immune expresssion of AQP-5 (Fig 2 d and e, respectively). Nevertheless, in August the cauda ductus epididymis had a mild response (Fig 2 f).

The main study's findings showed that the ductus epididymis of Saudi Arabian dromedary camels had positive response of AQP-5, which includes the caput, corpus, and cauda.

The ductus epididymis was separated histologically into three distinct regions: the head, body, and tail. The results of Axner *et al* (1999), who claimed that domestic cats epididymis is divided into six different sections, are in conflict with the current study. The present observations demonstrated that the ductus epididymis of the Saudi Arabian dromedary camel was lined with high-pseudostratified columnar epithelium with stereocilia. It was also encircled by circular smooth muscle fibres and a small amount of loose connective tissue. These findings support the result of Eurell and Frappier (2006) in domestic mammals and Saini *et al* (2023) in dromedary camel.

The results of this experiment showed that throughout the rutting and non-rutting seasons (winter and summer, respectively), AQP-5 was expressed in differing degrees in the caput, corpus, and cauda of the ductus epididymis. The corpus's epithelium demonstrated a notable immunological response to the AQP-5 at the beginning of the rutting season. This finding corroborates with Al-Thnaian (2023b) and Abdelhay (2024) who discovered those of AQP-1 and 9, respectively in dromedary camels. On the other hand, this research revealed a mild reaction of AQP-5 in the epithelium, muscle coat, and connective tissue of the caput epididymis in the rutting season (January).

Al-Thnaian (2023 a and b) and Abdelhay (2024) showed that the dromedary camel's epididymis consisted of aquaporin 1, 7 and 9, respectively.

These results may provide credence to the idea that AQP-5 is important for spermatozoa differentiation and maturation in dromedary camels during rutting and non-rutting seasons.

Conclusion

Based on these results AQP-5 may play the main factor influencing male dromedary camel fertility during the rutting and non-rutting seasons. Further future studies should consider the physiological roles of AQP-5 in the transportation of lipids, energy, and water in the camel male reproductive system.

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Conflict of interest

There is no conflict of interests of any sort between authors or elsewhere.

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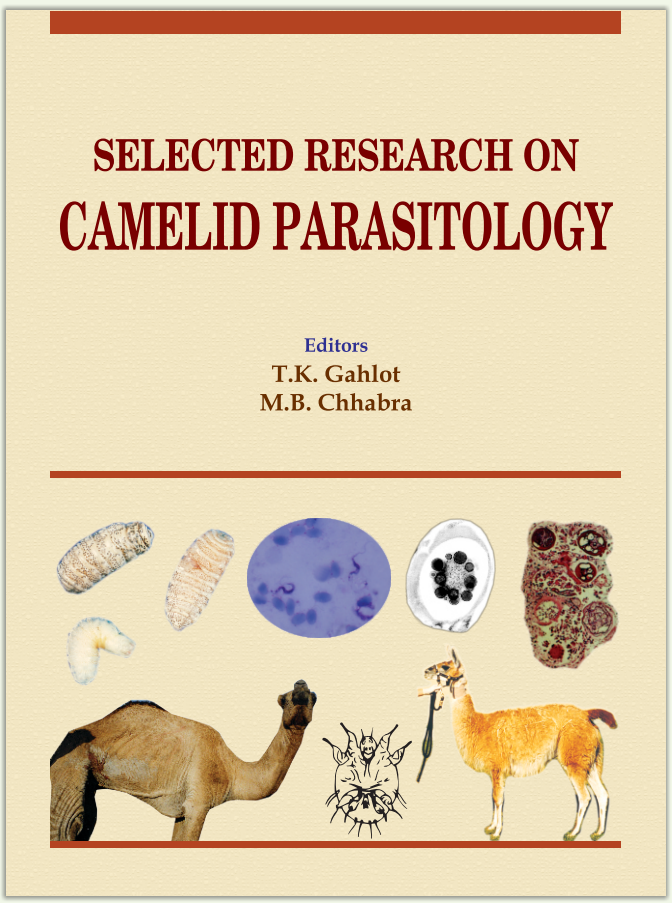

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HISTOLOGICAL STUDIES ON THE EXOCRINE PORTION OF THE PANCREAS IN THE SAUDI CAMEL (*Camelus dromedarius*)

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ABSTRACT

The general features of the exocrine portion of the pancreas of the Saudi camel were studied microscopically. Specimens from 25 camels (*Camelus dromedarius*) of varying ages (2–12 years) and sexes were used. Microscopic results revealed that the pancreas of camel consists of a mixed endocrine and exocrine portion. It is covered with a thick capsule of connective tissue of collagenous, reticular, elastic fibres and blood vessels. The gland parenchyma is divided into lobules by the connective tissue septa, which extends septa from the internal surface of the capsule. These septa were abundant in adipose tissue and contained collagenous, elastic, reticular fibres, blood arteries, ducts, nerve fibres and ganglion cells. The acinar type predominated among the tubuloacinar secretory units. The excretory ducts started as centroacinar cells and formed intercalated, intralobular, interlobular and the main pancreatic ducts. In conclusion, the histology of the exocrine component of the pancreas in camels was similar to that of other domestic animals with a higher degree of acinar type and adipose tissue invaded the septa. However, uniquely, there were acinar cells in the connective tissue of the large ducts observed only in the present study.

Key words: Camel, exocrine, histology, pancreas

The one-humped camel (*Camelus dromedarius*) is an important farm animal in Saudi Arabia. Its morphological and physiological adaptations enable it to withstand harsh desert environments (Soliman, 2015). However, studies on its organ structure and function are not enough. Investigating its pancreas can enhance understanding its anatomy, physiology, behaviour and pathology. The pancreas is a mix of exocrine and endocrine glands that release digestive enzymes and hormones (Ghaji, 2018).

The exocrine pancreas produces digestive enzymes, including lipase, trypsin and amylase and secretes them into the gut to facilitate food digestion (Pandol, 2015; Wallig *et al,* 2024). Structurally, it is covered by a thin connective tissue capsule extending into septa, dividing the organ into lobules. It consists of secretory units and a duct system; the units are compound tubuloacinar, while the duct system is composed of the centroacinar cells, intercalated ducts, intralobular ducts, interlobular ducts, the main pancreatic duct that lead to the hepatopancreatic duct (Dellmann and Brown, 1981; Mostafa *et al,* 1983; Wheater *et al,* 1992; Motta *et al,* 1997; Jarrar and Faye, 2013; Young *et al,* 2013; Tsuchitani *et al,* 2016; Hafez and Zaghloul, 2017; Longnecker *et al,* 2023; Wallig *et al,* 2024).

The anatomy of the endocrine portion of dromedary camel pancreas has been adequately studied (Adeghate, 1997; Jarrar and Faye, 2013; Hafez *et al,* 2015; Hafez and Zaghloul, 2017; Althnaian *et al,* 2019; Abdellatif, 2020; Attai *et al,* 2022; Rashwan, 2023). Hence, the present investigation was aimed to study the histology of the exocrine portion with its duct system of pancreas of camel using different stains.

Materials and Methods

Sampling

The pancreatic specimens were taken from 25 one-humped camels (*Camelus dromedarius*) of both sexes from the Al Omran slaughterhouse in Al-Ahsa, Saudi Arabia. The animals were between 2-12 years old and the specimens appeared normal.

The ethics committee of King Faisal University approved the animal protocol, which was followed in all animal sample procedures.

Tissue preparation

Small pieces of the pancreas were collected immediately after slaughtering. Samples were taken from the body, right and left lobes. The tissue was

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cut into slices and put into 10% buffered formalin for fixation. The collected specimens were dehydrated in ascending alcohol grades, cleared in xylene and embedded in paraffin wax. Tissue blocks were sectioned at 4–5 µm and mounted onto glass slides coated with either chrome alum gelatin or albumin. The slides were then cleared in xylene, rehydrated in descending grades of alcohol, washed in distilled water and stained with Haematoxylin and Eosin stain for general histology, Masson trichrome for collagen, aldehyde fuchsin for elastic fibres and Gordon & Sweet's method for reticular fibres (Stevens and Bancroft, 1990). Stained slides were then examined and photographed by a light microscope (Leitz, Germany) connected to a digital camera (Leica DFC420, Germany).

Results

The pancreas of camel was found as a mixed exocrine and endocrine gland covered with a dense connective tissue capsule consisting of collagenous, reticular and elastic fibres, numerous nerve fibres, blood vessels and highly infiltrated with adipose tissue (Figs 1a and 1b).

Connective tissue fibres from the capsule's interior stretched into the gland parenchyma, creating septa that separated it into lobules (Figs 1b and 1c). These septa comprised adipose tissue, collagenous, elastic, reticular fibres, blood arteries, ducts, nerve fibres and ganglion cells (Figs 1c and 1d).

The exocrine portion

The exocrine portion was comprised of the secretory units and the excretory ducts.

Secretory units

Secretary units were tubuloacinar (Figs 2a and 2b), with the acinar portion more prominent (Fig 2a). The acini comprised 5-9 cells arranged around a small central lumen. The secretory epithelial cells were pyramidal with spherical basal nuclei and a narrow lumen in the centre (Fig 2a). The apical part of the cytoplasm contained secretory granules. The reticular connective tissue networks and basal laminae encircled the acini (Fig 2c). The connective tissue of the major ducts contained a few acinar cells. (Fig 2d).

Duct system

The duct system of the exocrine portion of the pancreas started as flattened centroacinar cells (Fig 3a). These centroacinar cells were continuous with small ducts termed the intercalated ducts that were lined with flattened to a simple low cuboidal epithelium and supported by a basal lamina. The intercalated ducts led to the intralobular ducts inside the lobules and were lined by simple cuboidal epithelium. The epithelium rested upon a basal lamina and was supported by bundles of collagenous fibres (Fig 3b). The intralobular ducts joined to form the interlobular ducts, which were lined by simple cuboidal to low columnar epithelial cells (Fig 3c). A basal lamina and thick dense connective tissue layer supported the cells (Figs 3c and 3d). The interlobular ducts led to the main pancreatic duct, which was lined by simple columnar epithelium and supported by a basal lamina and a thick connective tissue layer (Fig 3e). The main pancreatic duct possessed dense elastic fibres (Fig 3f), groups of acinar cells and small ducts within its connective tissue layer (Figs 2d and 3e). The main pancreatic duct communicated with the bile duct to form the hepatopancreatic duct.

Discussion

The present study has shown that the pancreas of camel was a mixed exocrine and endocrine gland. The pancreas was covered with a dense connective tissue capsule containing collagenous, reticular, elastic fibres and blood vessels. The connective tissue capsule extended septa from the internal surface into the gland parenchyma, dividing it into lobules. These septa comprised collagenous, elastic and reticular fibres and were rich in adipose tissue. The septa also contained blood vessels, ducts, nerve fibres and ganglion cells. This confirms the previous finding in camel (Qayyum *et al,* 1987; Sultan and Ali, 1998; Hafez and Zaghloul, 2017; Attai *et al,* 2022).

Similar morphological observations had been reported in other domestic animals and man (Trautmann and Fiebiger, 1957; Coupland, 1958; Hirmatsu *et al,* 1993; Motta *et al,* 1997; El-sakhawy *et al,* 2016; Prakash *et al,* 2018; Mahesh *et al,* 2020). However, the high infiltration of the adipose tissue was a characteristic feature of the camel pancreas of this study. This adipose tissue had also been observed in the connective tissue septa of the pancreas of the guinea pig (Benseley, 1911; Dolenšek *et al,* 2015).

The exocrine portion of the pancreas findings in this study showed that it consisted mainly of secretory units and excretory ducts. The secretory units were tubuloacinars, with the acinar type more prominent. These findings confirmed previous results obtained in the camel pancreas (Tadjalli and Meamary, 1998; Sultan and Ali, 1998; Hafez and Zaghloul, 2017; Attai *et al,* 2022). Similar findings

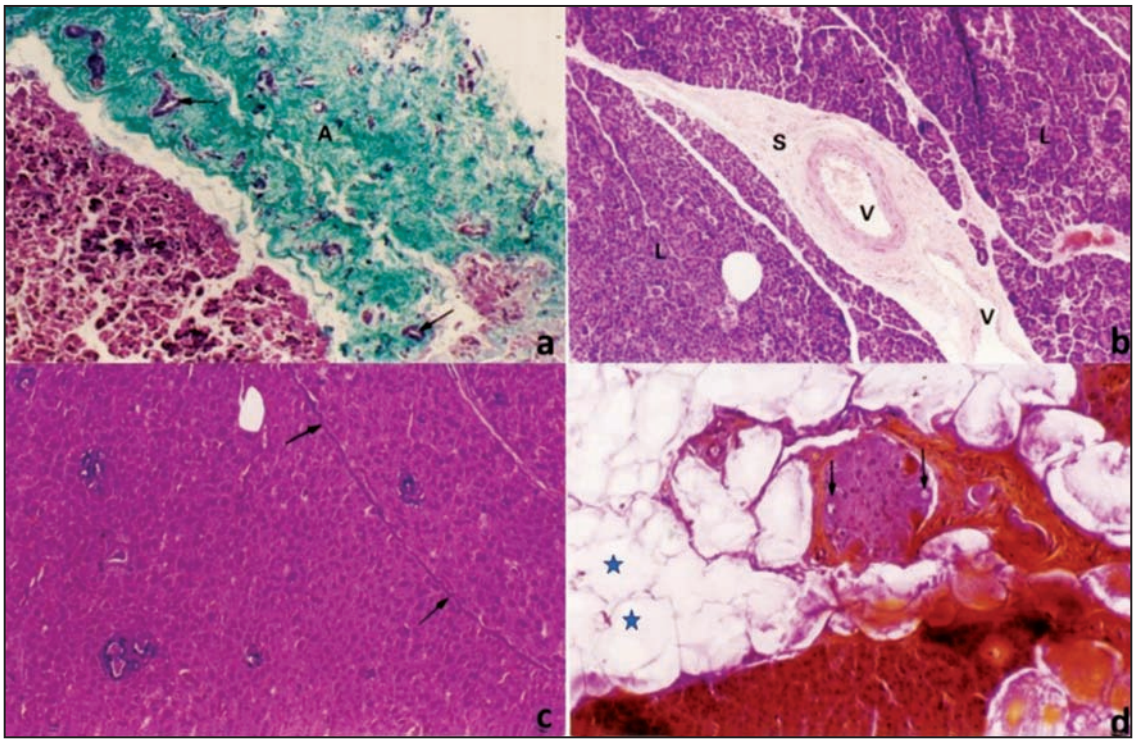

Fig 1. **(a)** A photomicrograph of camel pancreas showing a thick connective tissue capsule with collagenous fibres (A) and numerous blood vessels (arrows). Masson trichrome. X100. In **(b)**, there are lobules (L), separated by connective tissue septa (S) showing blood vessels (V). H and E. X100. While **(c)** verifying the elastic fibres in the connective tissue septa (arrows). Aldehyde fuchsin. X200. **(d)** showing ganglion cells in the connective tissue septa (arrows); adipose cells (stars). Modified aldehyde fuchsin method. X200.

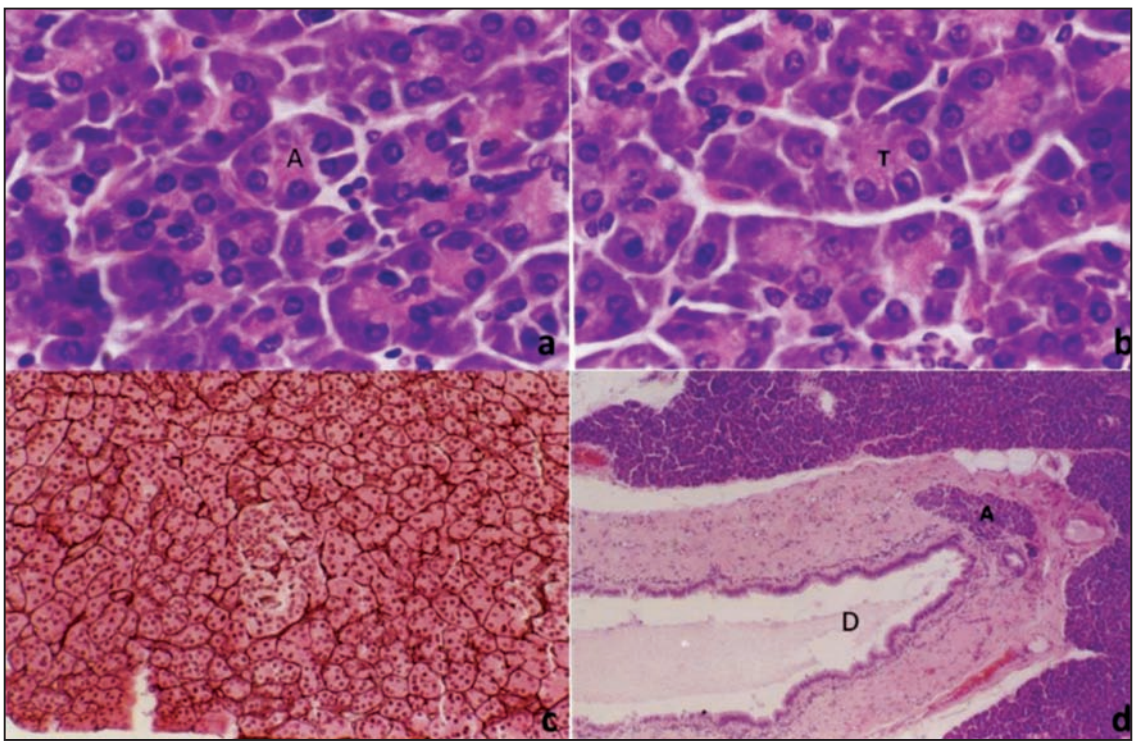

Fig 2. **(a)** Photomicrograph of the pancreas of the camel showing the abundant acinar-type secretory units (A). H and E.X1000. **(b)** A section of the pancreas of the camel showing tubular-type secretory units (T). H and E.X1000. **(c)** demonstrating the framework of the reticular connective tissue in the pancreas of the camel. Gordon and Sweet's method. X200. **(d)** showing some acinar cells in the connective tissue of a duct (A). H and E.X200.

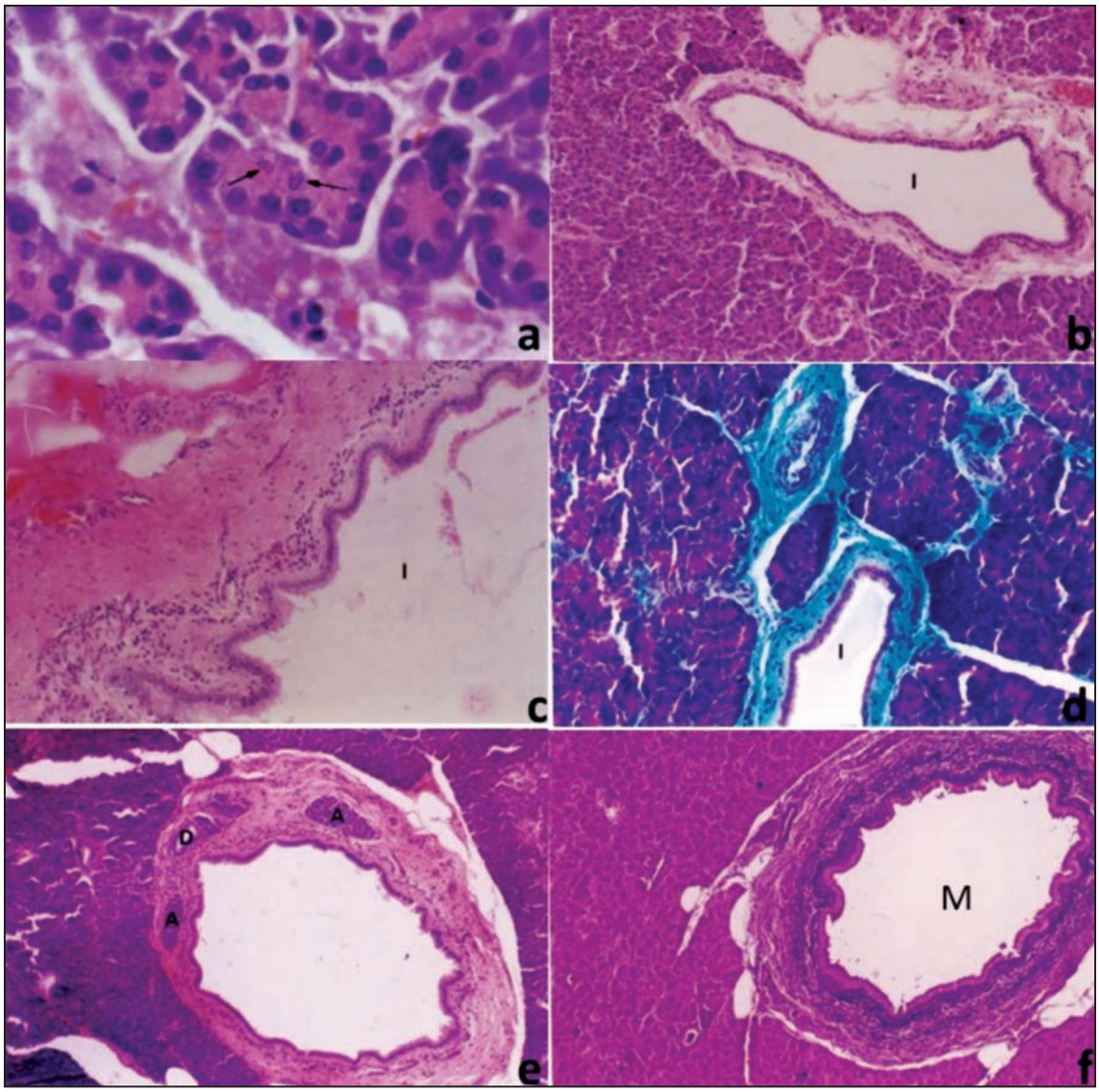

Fig 3. **(a)** A section of the pancreas of the camel showing centroacinar cells (arrows) in the acini. H and E. X1000. **(b)** showing an intralobular duct (I) lined with simple cuboidal epithelium. Bundles of collagenous fibres surround the epithelium. H and E. X200. **(c)** An interlobular duct (I) showing the low columnar epithelium and part of the thick connective tissue layer. H and E. X200. **(d)** A section through the parenchyma of the pancreas of the camel showing an interlobular duct (I) with thick collagenous fibres. Masson trichrome. X200. **(e)** The main pancreatic duct demonstrating the simple columnar epithelium, groups of acinar cells (A) and small duct (D) in the connective tissue layer. H and E. X100. **(f)** The main pancreatic duct (M) of the camel pancreas showing dense elastic fibres (black fibres). Aldehyde fuchsin. X100.

were reported in other animals and men (Ekholm *et al,* 1962; Laitio *et al,* 1974; Sisson, 1975; Dellman and Brown, 1981; Wheater *et al,* 1992; Mobini *et al,* 2008; Prakash *et al,* 2018; Mahesh *et al,* 2020). There were acinar cells in the connective tissue of the large ducts, a unique finding observed only in the present study.

The duct system of the camel pancreas started as centroacinar cells which were continuous, with the small ducts termed the intercalated ducts lined with a flattened to low cuboidal epithelium supported by a basal lamina. Similar findings were also observed in the camel (Tadjalli and Meamary, 1998) and other domestic animals (Gemmell and Heath, 1973; El-sakhawy *et al,* 2016; Mahesh *et al,* 2020). The intralobular duct was lined by simple cuboidal epithelial cells that rested on a basal lamina surrounded by bundles of collagenous fibres. This agreed with the findings in other animals and men (Kodama, 1983; Egerbacher and Böck, 1997; Tadjalli and Meamary, 1998). The interlobular duct was lined by a simple cuboidal to low columnar epithelium. A basal lamina and thick, dense connective tissue layer

supported the epithelial cells. Similar features had been reported by Kodama (1983), Wheater *et al* (1992) in other animals, Tadjalli and Meamary (1998) and Hafez and Zaghloul (2017) in camels.

The main pancreatic duct showed dense elastic fibres and small ducts within its thick connective tissue layer, which resembles the results in other animals and humans (McMinn and Kugler, 1961; Longnecker, 2014).

Conclusion

In conclusion, the histological structure of the exocrine portion of the camel pancreas was comparable to that of other domestic animals, with the tubuloacinar secretory units showing a greater degree of acinar type. The pancreas was covered by a connective tissue capsule and the septa were infiltrated with adipose tissue. In addition, some of the large interlobular and main pancreatic ducts contained acinar cells in their connective tissue walls.

Conflict of interest

None declared

Acknowledgements

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MORPHOLOGICAL AND TOPOGRAPHICAL STUDIES IN THE PANCREAS OF THE DROMEDARY CAMEL (*Camelus dromedarius*)

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ABSTRACT

A morphological study examined the overall characteristics of the dromedary camel's pancreas. The topographical, weighing and measuring investigation samples were from 15 camels (*Camelus dromedarius*) of both sexes and ages (4–15 years). The results showed that the camel pancreas was grayish pink in colour, weighing about 150 – 600 gm and had no definite shape. It was composed of a quadrilateral body, a long tongue-shaped left lobe, a short right lobe and a small accessory lobe. It was situated at the level from the first up to the fifth or sixth lumbar vertebrae. It has only one pancreatic duct, which is entirely embedded in the substance of the gland. The arterial blood supply of the camel pancreas was via the celiac trunk and the cranial mesenteric artery. In conclusion, the dromedary camel's pancreas resembled other domestic animals in terms of shape and topography. However, it was distinguished by the existence of a small accessory lobe.

Key words: Dromedary camel, morphology, pancreas, topography

The pancreas has a pivotal role in the digestive physiology of ruminants , specially in the digestion of ruminal fermentation products (including microbial cells) and ingested nutrients that escape fermentation in the rumen. As a digestive gland, the pancreas is composed of the endocrine part secreting hormones such as insulin and glucagon (Jenstad and Chaudhry, 2013) and the exocrine part secreting digestive enzymes such as amylase, protease and lipase, which play an important role in the growth, development, reproduction and production processes of animals (Long *et al,* 2021).

The pancreas in healthy camels has been studied grossly (Mostafa *et al,* 1983), histochemically (Qayyum *et al,* 1987) and ultrasonographically (Lakhel *et al,* 2025). In view of possible pathologies involving pancreas of camels, it is imperative to carry out an elaborate study on the gross anatomy of pancreas in camels. The present study was therefore aimed to study the morphology and topography of pancreas in camels.

Materials and Methods

Pancreatic samples were taken from 15 healthy dromedary camels (*Camelus dromedarius*) of both sexes (2- 12 years of age) from the Camel Research Centre at King Faisal University's College of Veterinary Medicine and Al Omran abattoir, Al-Ahsa.

For the gross anatomical study, measurements of the pancreas were taken from 13 fresh glands. The lengths of lobes were measured using a standard measuring tape. The electronic balance was used to weigh the samples. The means of the lengths of lobes and weights of the pancreas were calculated.

The topography and the arterial blood supply of the camel pancreas was studied in two animals. These were perfused with 10% formalin and dissected as described by Mohamed *et al* (2017).

The sample collection was followed in accordance to the guidelines of King Faisal University's ethical committee.

Results

It the gross anatomical study the camel's fresh pancreas was found grayish pink and weighed about 150 to 600 gm. It was covered with a significant amount of fat. The gland showed no definite shape and was composed of a quadrilateral body, long tongue-shaped left lobe, short right lobe and small accessory lobe (Fig 1A). The length of the body was 6-10 cm, the left lobe 22-38 cm, the right lobe 9-17

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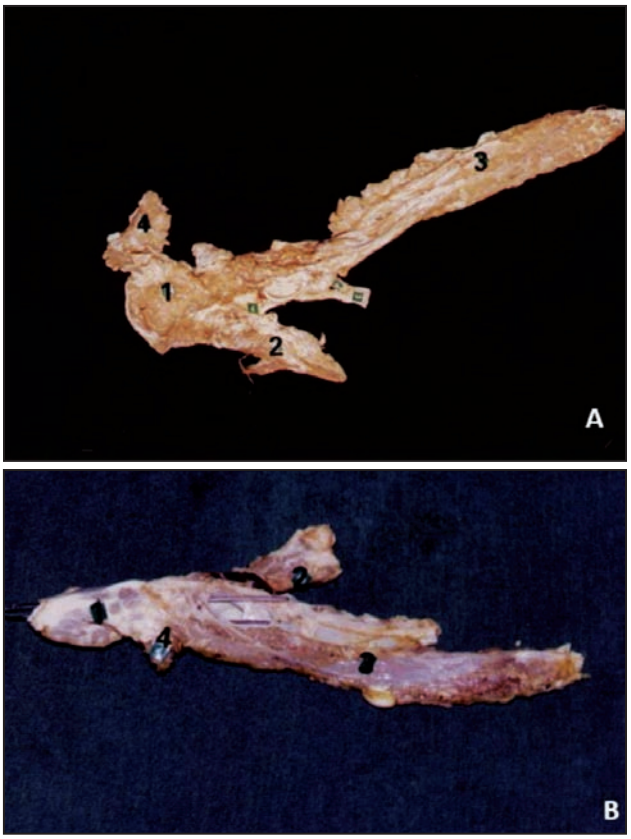

Fig 1. A. Photograph of the pancreas of the camel showing the different lobes: the body of the pancreas (1), the right lobe (2), the left lobe (3) and the accessory lobe (4).
B. Photograph of the pancreas of the camel showing the portal vein passing through the portal ring (the forceps). The body of the pancreas (1), the right lobe (2), the left lobe (3) and the accessory lobe (4) are shown.

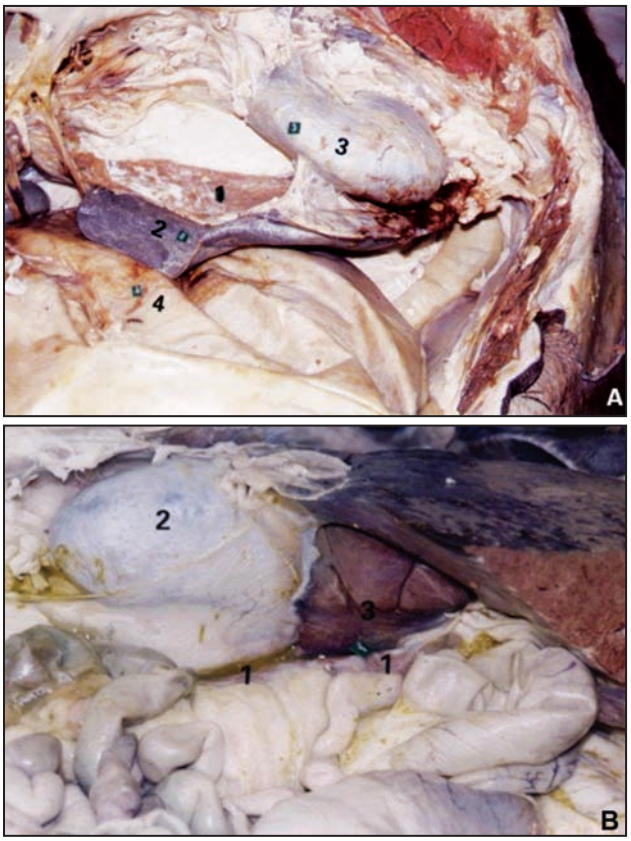

Fig 2. A. Photograph of the left view of the abdominal cavity of the camel showing the relationship of the left lobe of the pancreas (1) with the spleen (2), the left kidney (3) and the caudodorsal sac of the rumen (4).
B. Photograph of the right view of the abdominal cavity of the camel showing the relationship of the right lobe of the pancreas (1) with the right kidney (2) and the caudate lobe of the liver (3).

cm and the accessory lobe 3-7cm. The accessory lobe formed a small part that crossed dorsally over the portal vein from the right lobe to the left lobe and extended slightly lateral. It formed a ring through which the portal vein passes (Fig 1B).

The pancreas was extended from the level of the first to the fifth or sixth lumbar vertebrae. The body was related dorsally to the portal vein, the left crus of the diaphragm and the visceral surface of the liver and ventrally, it was related to the descending duodenum and the transverse colon. Cranially, it was associated with the ampulla of the duodenum. The left lobe was related cranially and ventrally to the caudodorsal sac of the rumen, while caudally and laterally, it was related to the spleen, left kidney and left adrenal. It was related dorsally to the ventral surface of the left kidney, spleen and descending colon (Fig. 2A). The right lobe of the pancreas was related dorsally to the right kidney, visceral surface of the caudate lobe of the liver, portal vein and cranial mesenteric artery (Fig 2B). Caudally, it was related to the second duodenal flexure, the transverse and descending colon.

There was only one pancreatic duct, which was entirely embedded in the gland's substance. The pancreatic duct joined the bile duct in the gland's substance to form the hepatopancreatic duct, which opened into the cranial duodenal flexure.

The pancreas's arterial blood supply emerged from the hepatic and splenic arteries of the celiac trunk and two branches of the cranial mesenteric artery.

Discussion

The present investigation revealed the morphological features of the pancreas of the adult camel of both sexes. The fresh pancreas of the camel was grayish-pink in colour. Similar findings were reported in this animal by Mostafa *et al* (1983), Sultan (1999) and Massad (2002). However, in domestic animals, it was reddish cream in horses (Bradley,

1946), pinkish yellow in sheep and ox (May, 1970; Dyce and Wensing, 1971; Terzić-Avdagić *et al,* 2023) and pinkish white or grayish-red in men (Williams, 1973; Terzić-Avdagić *et al,* 2023) and grayish pink to pale brown in donkey (Dhoolappa *et al,* 2004).

The weight of the camel pancreas ranged between 150 and 600 gm, which conforms with previous observations of the camel pancreas by Hegazi (1945) and Smuts and Bezuidenhout (1987). However, it showed slight variation in the ox and horse, in which the pancreas weighed about 350-500 gm (Habel, 1975) and 350 gm (Bradley, 1946). Meanwhile, in humans, it was 41 - 174 grams (Caglar *et al,* 2014).

In this study, the gland showed no definite shape and was composed of a quadrilateral body, long tongue-shape left lobe, short right lobe and small accessory lobe. Overall, our results aligned with earlier studies on the camel pancreas, while our results differed in the presence of the accessory lobe (Sultan, 1999; Taha and Magied, 1998). In contrast, the shape of the pancreas in the other animals and men showed some differences. The pancreas was triangular in shape in man (Cunningham and Romanes, 1977; Terzić-Avdagić *et al,* 2023), irregular triangle shape in the horse and donkey (Bradley, 1946; Dhoolappa *et al,* 2004), irregular quadrilateral shape in the ox and sheep (May, 1970; Frandson, 1986; Rafiq *et al,* 2024) and v-shaped in dog (Getty, 1975; Mostafa and Mohammed, 2022).

According to this study, the camel pancreas was located in the abdominal cavity between the first and fifth or sixth lumbar vertebrae. Mostafa *et al* (1983), Sultan (1999), Taha and Magied (1998) and Massad (2002) reported similar findings. However, the pancreas was situated ventral to the upper part of the last rib and the first lumber transverse process in sheep (May, 1970; Rafiq *et al,* 2024), ventral to the sixteenth, seventeenth and eighteenth thoracic vertebrae in the horse and donkey (Bradley, 1946; Dhoolappa *et al,* 2004) and ventral to the first, second and third transverse processes of the lumbar vertebrae in ox (Frandson, 1986).

The findings of present study showed only one pancreatic duct, which was entirely embedded in the gland's substance. This duct joined the bile duct to form the hepatopancreatic duct. There have been prior reports of equivalent results in the camel pancreas (Mostafa *et al,* 1983; Sultan, 1999; Taha and Abdel Magied, 1998). In mammals, the pancreas is generally drained by two ducts, the greater and the accessory pancreatic duct. Nonetheless, the terminal portion of one of these ducts regresses in certain animals. Cows, Swamp buffaloes and pigs only have the accessory duct (Wass, 1965; Rung-ruangkijkrai and Klomkleaw, 2014), while small ruminants only have the larger duct (Dyce *et al,* 1987; Rafiq *et al,* 2024). Two ducts were found in humans, dogs, cats, donkeys, horses and monkeys (Millis, 1949; Nielson and Bishop, 1954; McMinn and Kugler, 1961; Neto, 1977; Dhoolappa *et al,* 2004).

This study has demonstrated that the hepatic and splenic arteries of the celiac trunk and two branches of the cranial mesenteric artery are the source of the camel's pancreatic arterial blood supply. These results support previous studies on camels by Sultan (1999) and Mostafa *et al* (1983) and other species by Bertelli *et al* (1997) and Carioto (2016).

Conclusion

In conclusion, the macroscopic findings of the camel pancreas were grayish pink, weighing about 150 – 600 gm and had no definite shape. It comprised a quadrilateral body, a long tongue-shaped left lobe, a short right lobe and a distinctive small accessory lobe. It was situated at the level from the first up to the fifth or sixth lumbar vertebrae and has only one pancreatic duct, which is entirely embedded in the substance of the gland. The arterial blood supply of the camel pancreas was via the celiac trunk and the cranial mesenteric artery.

Conflict of interest

None declared

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MACRO MORPHOLOGICAL STUDIES ON THE UTERUS OF SHE-CAMEL (*Camelus dromedarius*)

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ABSTRACT

The study of the reproductive female camel was focused on the structure and positioning of the uterus. The uterus, a large, thick-walled muscular organ, was found to house embryos until birth and appeared red or greyish-white in colour. Located between the pelvic and abdominal cavities, the uterus was supported by the broad ligaments, which comprised peritoneum, muscle fibres, and connective tissue. This ligament is connected cranially to the ilium and caudally to the sacrum. The uterus was divided into two parts: the cranial transverse part, consisting of the uterine horns, and the caudal longitudinal part, forming the uterus body. The uterus of camels exhibited a T-shape rather than the classical Y-shape, with the left horn being significantly longer than the right. Blood supply was provided by the middle uterine artery. The study also noted the absence of caruncles in the uterine body and horns, with the endometrial surface showing variations in colour from creamy to red depending on functional state. Detailed measurements indicated differences in length and circumference between the left and right horns, with the left being larger. The findings highlighted the complex and adaptive nature of the camel's reproductive system, essential for its survival in harsh desert environments.

Key words: Broad ligament, camel, reproductive system, uterine body, uterine horn, uterus

Animal output is mostly determined by their reproductive ability. The key to profitable large animal production is consistent and successful reproduction (Arata, 2015). Reproductive efficiency is a key factor in maximising the animal's profit (Khaton *et al,* 2015). Seasonally polyestrous and induced ovulates are found in both dromedary and Bactrian camels which normally only ovulate in response to mating (Sghiri and Driancourt, 1999). The short breeding season, the late age of puberty, the long gestation period and the long interval between births due to prolonged lactation-related anoestrus are all factors contributing to the low reproductive efficiency (Skidmore, 2003).

In mammals, the uterus is an important organ for reproduction. It is necessary for the female fertility, health and offspring. It is divided into two horns and body (Khaton *et al,* 2015, Ghazi, 1981). In camels, the uterus is bicornuate, meaning it has two distinct horns that connect to the fallopian tubes (Porjoosh *et al,* 2010).

The female genital tracts of camelids have previously been studied for reproductive purposes (Skidmore and Adams, 2003). However, present study was aimed for the macro-morphological studies on the uterus of dromedary camels.

Materials and Methods

The female reproductive tracts of six recently deceased camels, free of any reproductive system pathology, were used for the current study. They were obtained from the Veterinary Clinical Complex, RAJUVAS, Bikaner, and examined in the Department of Veterinary Anatomy, College of Veterinary and Animal Science, Bikaner. Topographical and gross examinations of the uterus of every camel was conducted immediately after death and collected uteri were fixed in 10% neutral buffered formalin. Prior to fixation, the colour and shape of seen uterus were noted. Using a weighing scale, the organs' weight was determined. Utilising a measuring scale, the length was measred. The circumference and length of uterus was measured by wrapping a thread around the organ and recorded on the measuring scale. The mean and standard error were calculated for length and circumference of uterine horns and body.

Results and Discussion

The uterus appeared red or grayish-white in colour. The uterus was a thick-walled, hollow muscular organ that was partially located in the pelvic cavity and almost in the abdominal cavity, between the bladder below and the colon and rectum above.

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The camel's uterus was situated under the 5th, 6th, and 7th lumbar vertebrae in the abdominal cavity (Fig 2, 3). It was more caudal in young females. This finding agreed with the observations of Novoa (1970) and Jarrar and Faye (2015) in camel. Whereas, Skidmore and Adams (2003) reported that in nulliparous females the uterus was very small and found entirely within the pelvic cavity, whereas in mature non-pregnant females it was located in the abdominal cavity at the level of the 5th, 6th and 7th lumbar vertebra.

The genital fold was a transverse peritoneal fold that ran between the dorsal side of the bladder and the inferior face of the rectum. Due to presence of the reproductive tract in female, the genital fold was extended to cover the uterus and a small portion of the vagina. It was formed of two large folds, the broad ligaments of uterus, which attached the organ to the sides of the pelvic cavity and upper part of the flanks below the level of tuber coxae. Hence, the recto-vesical pouch was entirely divided into the recto-genital and vesico-genital pouches, which were located in the dorsal and ventral compartments (Fig 2, 3).

The broad ligament was made up of double folds of peritoneum, muscle fibres and connective tissue. The nerves and vessels leading to the uterus were passing through it. The broad ligament was connected cranially to the shaft of the ilium and caudally to the sacrum. These findings were in agreement with Jarrar and Faye (2015). A round ligament that arose from the ventro-lateral aspect of the broad ligament fixed the uterus in camels and similar observations were roeported by Ball and Peters (2004) in cattle. Mesometrium was seen as a part of the broad ligament that supports the uterus (Fig 2, 3, 4).

The mesometrium was attached at the vetro-lateral aspect of the uterus and it made the uterine surface flat ventrally and convex dorsally. The uterus was connected caudally to the cervix and cranially to the oviducts. The middle uterine artery, which was the largest of the uterine and utero-ovarian arteries, supplied blood to the reproductive tract (Fig 2, 3, 4).

The uterus was divided into two distinct parts: the cranial transverse part, which was made up of the free portion of uterine horns, and the caudal longitudinal part, which was made up of the fused part of horns and served as the uterus body (Fig 3, 4, 5) which was also noticed by Novoa (1970), Musa *et al* (1993), Tibary and Anouassi (2001), Srikanda kumar *et al* (2003) and Porjoosh *et al* (2010) in camel. A long inter-cornual septum was responsible for dividing the uterus which was also reported by Tibary and Anouassi (2001) in camel (Fig 3, 4, 5). There were two uterine horns, i.e. the right and left. Each horn was a muscular spiral tube with a cranial tapered that connects to the oviduct which was also described by Arthur *et al* (1985) in camel. Camels had a bicornuate uterus, with the left horn being noticeably longer than the right. The uterus of a camel resembled a letter T more so than the classical Y shape (Fig 3, 4, 5). These findings resembled with those of Ghazi (1981) in camel.

The body of the uterus measured 4.93 ± 0.75 cm in length and 11.17 ± 0.98 cm in circumference whereas according to Skidmore and Adams (2003) non-gravid uterus had a short body of only 2 - 3.5 cm in length and according to Srikanda kumar *et al* (2003) body of uterus was 20-35 mm (2cm-3.5) in length in camel (Table 1). Body of uterus appeared to be longer because the caudal most portions of the horns before they fused had a shared peritoneal covering. Its upper surface was convex while its lower surface was flat. The wall of uterine body was thicker than horns. The body was continued caudally with the cervix and bifurcates cranially to form horns. The uterine body was relatively short. The caudal portions of the cornua were intimately united together. The findings were in agreement with reports of Novoa (1970) in camel that the uterus had a flat lower surface and a convex upper surface. The uterine body was relatively short. The cornua of uterus were intimately united in their caudal portions. Porjoosh *et al* (2010) also measured the length and diameter of the uterine body as 65 ± 9.4 mm (6.5cm ± 0.94cm) and 65 ± 15.5 mm (6.5cm ± 1.55cm), respectively. Inter-conual ligament was absent in the uterus of camel. Jarrar and Faye (2015) observed that the uterine body was relatively short 2.5 to 4 cm in length and diameter (Fig 5, 6).

The horns or cornua were varying greatly in length and the uterine body and horns were typically laid within the abdomen above the bulk of intestines. A long inter-cornual septum was formed between two horns. Horns were directed downward, forward, outward, backward, and then upward. The cranial sections diverged, forming a T-shape rather than a Y-shape with the uterine body (Fig 2, 4, 5, 6). These findings were in harmony with the findings of Novoa (1970), Tibary and Anouassi (2001) and Srikanda kumar *et al* (2003) in camel. The colour of the horn changed from light to dark purple, and the cranial free border of the horn appeared more convex than it did caudally (Fig 2, 4, 5, 6).

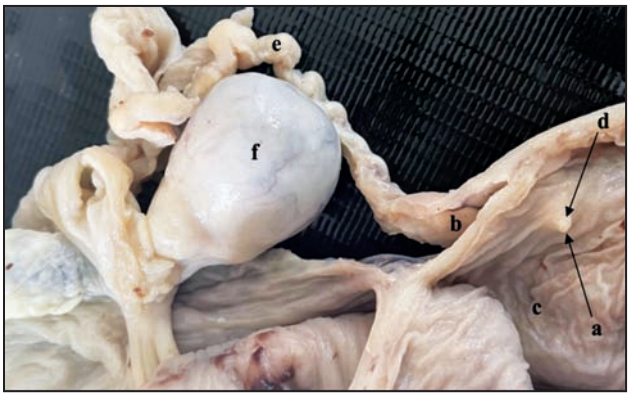

Fig 1. Photograph showing the oviduct entering into the uterine horn. a. ostium uterinum tubae, b. Intramural part of the oviduct, c. Uterine horn, d. Pyramid-shaped papilla, e. Oviduct and f. ovary with CL.

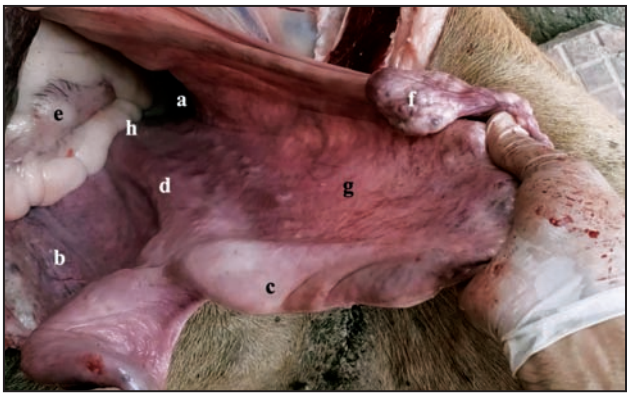

Fig 2. Photograph showing the dorsal surface of the uterus and uterine horn. a. Pelvic cavity, b. Abdominal cavity, c. Uterine horn d. Uterine body, e. Rectum and colon f. Left ovary, g. Broad ligament (Mesometrium) and h. Recto-genital pouch.

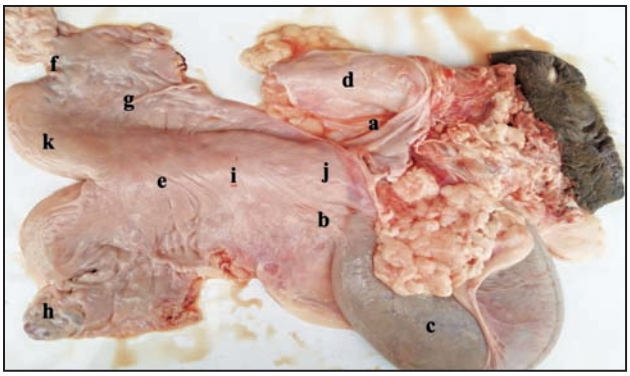

Fig 3. Photograph showing ventral surface of the uterus and uterine horn. a. Recto-genital pouch, b. Vesico-genital pouch, c. Urinary bladder, d. Rectum and colon, e. Uterine body, f. Oviduct, g. Broad ligament, h. Right ovary, i. Cervix, j. Vagina, k. Left horn and l. Right horn.

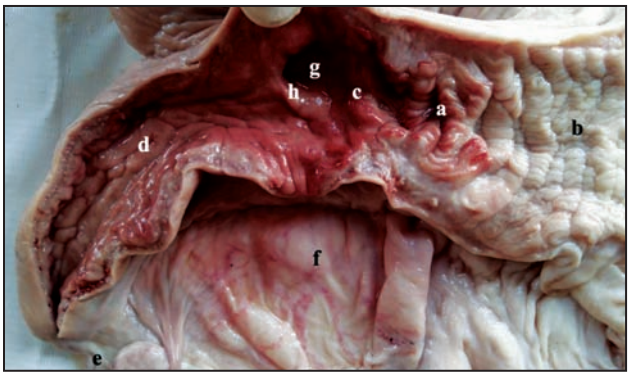

Fig 4. Photograph showing the Uterine body and horn. a. Cervix, b. Vagina, c. Body of Uterus, d. Left horn of uterus, e. Oviduct, f. Mesometrium, g. Opening of right uterine horn and h. Inter cornual septum.

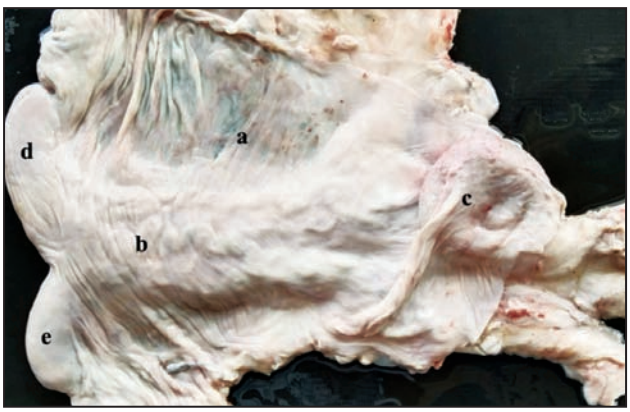

Fig 5. Photograph showing Ventral surface of the uterus. a. Mesometrium, b. Body of uterus, c. Urinary bladder, d. Left horn of uterus and e. Right horn of uterus.

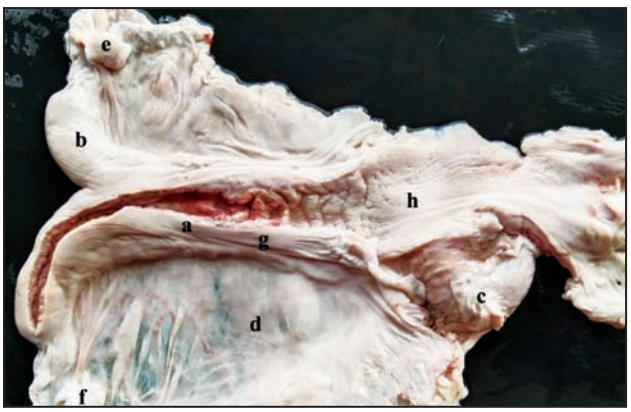

Fig 6. Photograph showing dorsal surface of the reproductive system of she-camel. a. Uterine body, b. Uterine horn, c. Urinary bladder, d. Broad ligament, e. Right ovary, f. Left Ovary, g. Cervix and h. Vagina.

The horns were likewise relatively straight, with visible utero-tubal papillae that protruded into the uterine lumen for a few millimeters and a sharp decline in breadth at their free end. Conical or pyramidal papillae that extended into the uterine lumen appeared to represent the connections between the distal ends of the two oviduct and the uterine horns. These findings were in conformity with the

Table 1. Morphometrical measurements of the uterus of camel.

Serial no.	Left horn		Right horn		Body of Uterus	
	Length	Circumference	Length	Circumference	Length	Circumference
1.	18.50	11.00	18.50	11.00	4.00	10.00
2.	20.00	11.50	19.20	10.50	4.00	10.00
3.	18.00	8.50	13.00	7.50	5.50	12.00
4.	18.60	11.00	16.00	9.00	5.00	11.00
5.	18.00	10.00	15.00	8.00	5.50	12.00
6.	19.00	12.00	17.00	10.00	5.60	12.00
Mean	18.68	10.67	16.45	9.33	4.93	11.17
SD	0.74944424	1.251666	2.292379	1.402379	0.752773	0.983192
SE	0.30595933	0.51099	0.93586	0.572519	0.307318	0.401386

findings of Tibary and Anouassi (2001) in camel (Fig 1). The camel's uterus lacked an inter-conual ligament (Fig 1) which was favoured by the observation of Porjoosh *et al* (2010) in camel.

Comparatively, the left horn was longer than right horn. The left horn measured 18.68 ± 0.75 cm in length and 10.67 ± 1.25 cm in circumference. The right horn measured 16.45 ± 2.29 cm in length and 9.33 ± 1.40 cm in circumference. These different from those oberved by Skidmore and Adams (2003) who found that the horns vary between 6 - 10 cm (right) and 8 - 15 cm (left). In Bactrian camels the right and left horns measured between 6 - 8 cm and 8 - 12 cm, respectively. These findings were in partial harmony with the Srikanda kumar *et al* (2003) that the left horn was longer than the right even in the foetus of camel. But differed in the measurements of the non-gravid uterus of a dromedary female which had horns that ranged from 60 – 100 mm (6-10cm) (right) and 80 – 150 mm (8-15cm) (left) (Table 1).

There were no caruncles in the uterine body and horn's mucous membrane (endometrium) in camels of present study which was favoured by the statement of Novoa (1970) and Ghazi (1981) in camel (Fig 4). The thickness of the uterine wall was 3 to 10 mm. The endometrium of left horn had irregularly raised longitudinal folds that were less noticeable than in right horn (Fig 4) which was also reported by Arthur *et al* (1985), Arthur *et al* (1998) and Tibary and Anouassi (2001) in camel. The inner surface was found smooth, flat, or undulating with varying degrees of endometrial fold development. It was primarily white in colour, with several prominences (endometrial folds), but in the uterine body, it was smooth. The surface showed colour variation, ranging from creamy to red, depending on its functional state. Depending on the uterus functioning state, the inner surface of the endometrium ranges in colour from white to red and was somewhat grayish which was similar with the findings of Jarrar and Faye (2015) in camel (Fig 4).

Conclusion

The camel's uterus was a large, thick-walled, muscular organ situated at the level of the 5th, 6^{t}h, and 7th lumbar vertebrae in the abdominal cavity, extending into the pelvic region. It exhibited a T-shaped bicornuate structure with two distinct horns, the left being longer than the right. The uterus was supported by broad ligaments composed of double folds of peritoneum, muscle fibres, and connective tissue, which also facilitated the passage of nerves and blood vessels. The uterine body, relatively short and thick-walled was connected caudally to the cervix and cranially to the oviducts, with blood supply primarily from the middle uterine artery. Notably, the uterus lacked caruncles and exhibited colour variations in the endometrial surface, ranging from white to red depending on its functional state, underscoring its specialised reproductive adaptations.

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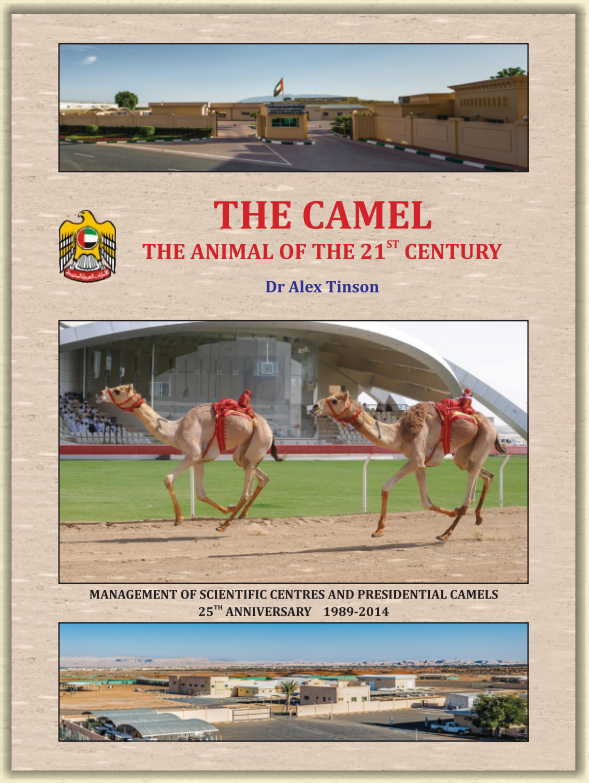
THE CAMEL

THE ANIMAL OF THE 21ST CENTURY

This book authored by Dr Alex Tinson is an acknowledgement to the support and inspiration that His Highness Sheikh Khalifa Bin Zayed Al Nahyan has provided to the centre and to research in general. The last 25 years has been an incredible adventure for us, the noble camel and the people of the U.A.E. Dr Tinson has been involved with many world first's since moving to Abu Dhabi 25 yrs ago. First there was the establishment of pioneering centres in exercise physiology and assisted reproduction. The establishment of the Hilli Embryo Transfer Centre led to five world firsts in reproduction. The world's first successful embryo transfer calf birth in 1990, followed by frozen embryo transfer births in 1994, twin split calves in 1999, pre-sexed embryo births in 2001 and world's first calf born from A.I. of frozen semen in 2013. The hard bound book is spread in 288 pages with 5 chapters. The first chapter involves early history of the centre, world's firsts, world press releases, history of domestication and distribution, evolution of camel racing in the U.A.E. and historical photos the early days. Second chapter comprises camel in health and disease and it involves cardiovascular, haemopoetic, digestive, musculoskeletal, reproductive, respiratory, urinary and nervous systems in addition to the description of special senses. This chapter describes infectious, parasitic and skin diseases in addition to the nutrition. The third chapter is based on Examination and Differential Diagnosis. The fourth chapter is based on special technologies bearing description of anaesthesia and pain management in camels, diagnostic ultrasound and X-Ray, assisted reproduction in camels, drug and DNA testing and surgery. The last chapter entailed future scope of current research.



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GROSS MORPHOLOGICAL STUDIES ON THE OVARIES OF SHE-CAMEL (*Camelus dromedarius*)

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ABSTRACT

In this study, the ovaries of six female camels (*Camelus dromedarius*) were examined gross morphologically. The ovaries were located at the level of the 6th and 7th lumbar vertebrae and were suspended by the broad ligament, with the left ovary commonly positioned more cranio-ventrally than the right. The ovaries were connected to the broad ligament by the ovarian ligament. Young camels exhibited a thinner broad ligament compared to older ones. Each ovary was enclosed by the bursa ovarica, with fimbriae of the oviduct attached at the hilus. The size and appearance of the ovaries varied with the animal's age and reproductive activity, becoming more irregular and lobulated with age due to follicles, corpus luteum, and corpus albicans. Each ovary had two borders, ends, and surfaces, with visible follicles and corpora lutea during the breeding season. The left ovary was generally larger than the right, with mature corpus luteum being compact and spherical. The size of Graafian follicles ranged from 1.5 to 3.0 cm. The study found that the left ovary measured larger in all dimensions compared to the right ovary.

Key words: Broad ligament, dromedary camels, follicles, ovary, reproductive system

Camels are though seasonal breeders but are induced ovulators (Novoa, 1970). They have a relatively short breeding period during which ovarian activity is increased (Sghiri and Driancourt, 1999).

Camels have successive follicular waves, each consisting of growth phase, maturation phase and regression phase. During the growth phase usually one follicle becomes dominant from a cohort of small follicles and continues the growth. During the maturation phase, the dominant follicle ovulates if mating occurs, otherwise it could continue to grow (large anovulatory follicle) or regress (regression phase). The follicular development depends on the concentration of estrogen which reaches its maximum when one dominant follicle is present in the ovary (Skidmore, 2011).

The ovary is an important endocrine organ in the female body, as it is the primary source of sex steroids. As a result, a healthy ovary is required for the proper function and maintenance of the female reproductive tract, mammary gland and sexual behaviour (Couse and Korach, 1999; Mayes, 2002 and Rodgers *et al,* 2003).

Anatomical studies of the ovary and oviduct in camel (*Camelus dromedarius*) has been studied (Abdalla, 1966, Musa, 1979 and Salari et al, 2011). Hidaia and Osman (2021) investigated the topography of the ovary in relation to the mesonephros and metanephros, time of descent of the ovary, the gross anatomy of the ovary during the three trimesters in camels. The present study was aimed to study the gross morphological studies on the ovaries of she-camels.

Materials and Methods

The ovaries of six recently died she- camels which were free from any pathological condition of reproductive system, were collected. These animals were brought to the Veterinary Clinical Complex, RAJUVAS, Bikaner. The collected samples were fixed in 10% Neutral buffered formalin. The shape and colour of the organs were recorded before fixation. The ovaries were used for the further study and recording of biometrical parameters. The weight of each ovary was measured by a weighing scale. The length was recorded by measuring scale. The circumference was measured by encircling a thread around the organ and then measured this length on the measuring scale. The width and thickness of the ovaries were measured by Vernier's caliper. The ovaries were dissected out by opening the abdominal cavity and pelvic cavity. The gross and topographic anatomical examinations of the ovaries were done.

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The mean and standard error of various parameters of the ovaries were calculated.

Results and Discussion

In the present study, left and right ovaries were found at the level of the 6th and 7th lumbar vertebra and 6 - 7 cm from crest of ilium. The ovaries were found hanging by the broad ligament. This finding resembled the reports of Jarrar and Faye (2015) in camel. The left ovary was largely visible under the left horn. More frequently, the right ovary was detected lateral to the right horn, a finding which is in agreement with the observation of Dyce *et al* (2010) in domestic animals. The left ovary was commonly further cranio-ventral in position than the right ovary (Fig 1, 2). This finding was in congruence with the observation of Skidmore and Adams (2003) in camel. In cattle these ovaries were laid slightly medial to the tips of the uterine horns to which they were connected directly by portions of the broad ligaments, the ovarian ligament (Ball and Peters, 2004).

Ovaries were connecting to the broad ligament by an ovarian ligament, also known as the proper ligament, which extended from the ovarian hilus to the tip of the adjacent uterine horn. These findings resembled to that of El-Wishy (1988) and Skidmore and Adams (2003) in camel. The ovarian ligament or proper ligament was present at mid distance between the ovary and lateral border of the uterine horn. When compared to older animals, young animals had a thinner broad ligament, which get thicker with age (Fig 3).

The ovary was enclosed by the bursa ovarica, a long, conical, pocket-like fold of the mesosalpinx. The findings of the present study were in conformity with the reports of Novoa (1970) and El-Wishy (1988) in camel. Arthur *et al* (1985) noted that the mesosalpinx and the mesovarium together formed a very well-developed bursa which closely invests the ovary in camels.The oviduct's fimbriae were located within a large, circular orifice that forms the bursa's apex (Fig 4). At the hilus of the ovary the fimbriae of the oviduct were attached closely. It was in agreement with the reports of Skidmore and Adams (2003), Novoa (1970) and Ali and Derar (2020) in camel.

Size and general appearance of the ovaries varied according to the activity and age of the animal. Primarily, the ovaries were small, bean-shaped, pinkish white in colour, and basically smooth, glistening, only with one or two grooves (Fig 5). In adult animals ovaries were more irregular, reddish, lobulated, or granular in appearance. Due to the presence of more raised vesicles (follicles), large follicles, corpus luteum, and corpus albicans with increasing age, the ovaries were more irregular in shape. Ovaries were shaped into a cluster by these bodies (Follicles) and resembled a "bunch of grapes". Multiple ovisacs on the surface of the ovary resembled a pear or nut in appearance. These findings resembled to that of Novoa (1970), in which the shape of camel ovary was pear or nut with many ovisacs on its surface. The camel ovaries were flattened, reddish, lobulated organ with a circular outline. The ovaries of camels were found broad bean shape (Ghazi, 1981) and granular in appearance due to small follicles around 3-5 mm in diameter (El-Wishy 1988). However, Skidmore and Adams (2003) found that the camel ovaries had a smooth and glistening surface with several raised small vesicles (2 - 5 mm) throughout the surface. They also found that the ovaries were oval or circular, flattened laterally and had an irregular surface due to many small follicles. Present findings favoured the observation of Ismail (1987) in camel who found that the ovaries were oval, flattened and lobulated organs and there was presence of numerous follicles which gave the ovary an appearance of a bunch of grapes (Fig 6, 7 and 8).

Each ovary had two borders, two ends and two surfaces. The attached border (medial) of ovary was also known as mesovarial border and had a shallow hilus of the ovary, from here vessels and nerves enter and leave the organ. Both the borders as well as the cranial and caudal ends were convex. The cranial end was also known as oviductal or tubal end. This end was wide and fimbriae of the infundibulum were attached with it (Fig 4). The caudal end was narrow and rounded. The medial and lateral surfaces were irregular and somewhat convex (Fig 5, 9). The present findings were in partial harmony with the findings of Ismail (1987) who reported in camel that the lateral and medial surfaces were slightly convex and the free border was also convex but the attached border was straight. El-Wishy (1988) found camel ovaries flattened laterally and somewhat convex at the lateral and medial surfaces, Novoa (1970) found the hilus a somewhat straight, and the lateral and medial surfaces were slightly convex; Jarrar and Faye (2015) found that the ovary of camel as oval, flattened laterally, and were slightly convex medial and lateral surfaces.

On the surface of each investigating ovary, many follicles of various sizes were visible, including a few elevated vesicles and one or two small growing follicles which were transparent (Fig 6, 7).

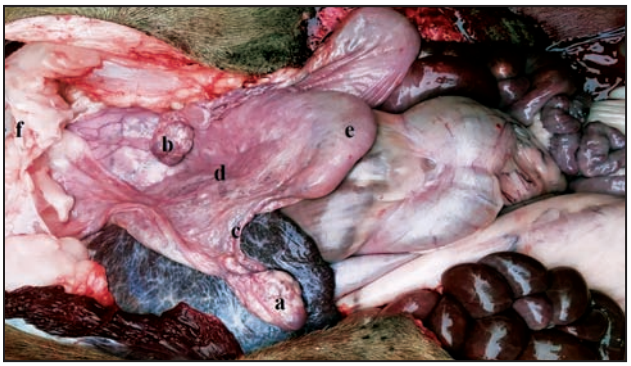

Fig 1. Ventral view of reproductive tract of she-camel. a. Left Ovary, b. Right Ovary c. Oviduct, d. Broad Ligament, e. Horn of uterus and f. Crest of ilium.

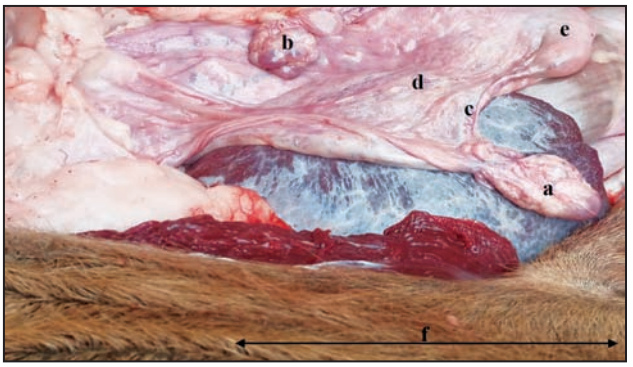

Fig 2. Left Lateral view of reproductive tract of she-camel. a. Left Ovary, b. Right Ovary c. Oviduct, d. Broad Ligament, e. Horn of uterus and f. Site of the Lumbar Vertebrae.

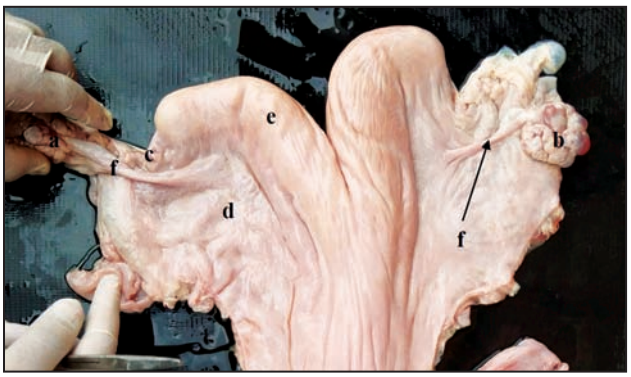

Fig 3. Dorsal view of the reproductive tract of she-camel. a. Left Ovary, b. Right Ovary c. Oviduct, d. Broad Ligament, e. Left horn of uterus and f. Proper ligament of Ovary.

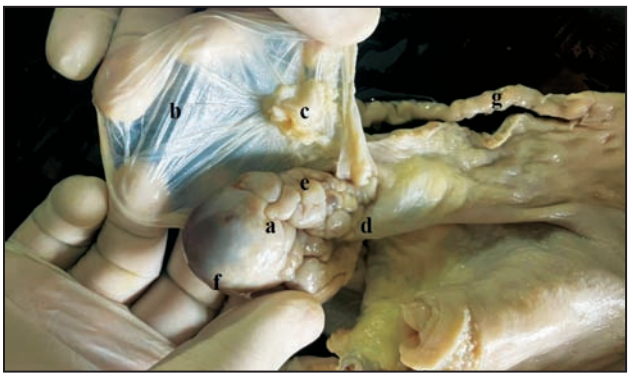

Fig 4. Left ovary of she-camel showing ends, bursa and infundibulum. a. Left Ovary, b. Bursa ovarica c. Infundibulum and Fimbria, d. Hilus of ovary, e. Oviductal end, f. Caudal end and g. Isthmus.

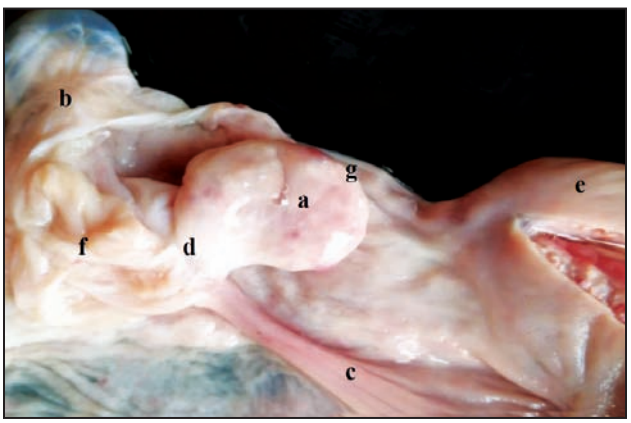

Fig 5. Left ovary of she-camel showing its medial surface. a. Left Ovary, b. Bursa ovarica or Mesovarium c. Proper ligament of ovary, d. Hilus of ovary (Attached border), e. Left uterine horn, f. Infundibulum and g. Free border.

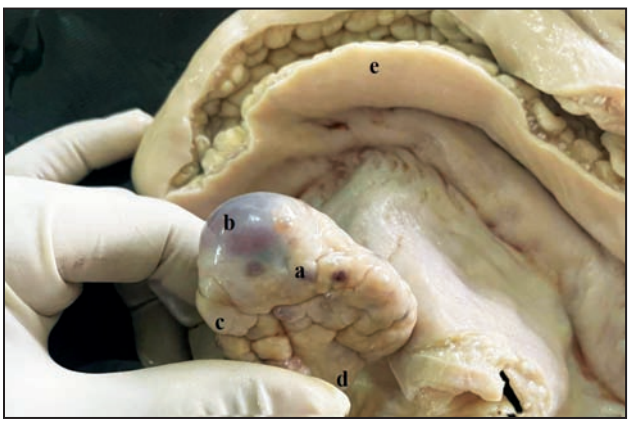

Fig 6. Left ovary of she-camel. a. Left Ovary, b. Large raised follicle (pyriform), c. Corpus Albicans, d. Hilus of ovary and e. Left uterine horn.

The ovary takes on a more lobular form during the breeding season when mature follicles and copora lutea (CL) protrude from the main contour. The lobulation was mostly caused by the presence of old corpora albicantia and increasing with more previous ovulations or pregnancies. One or two ovaries contained one or two periform, white, regressing corpus luteums and one or two small growing follicles which were in accordance with findings of Arthur *et al* (1985) in she camel. Skidmore and Adams (2003) also found that the mature follicles and current CL project from the main contour of the ovary and give it a more lobular form in camels. During pregnancy the ovaries increase in weight due to bearing the CL. Present study also favoured the statement of

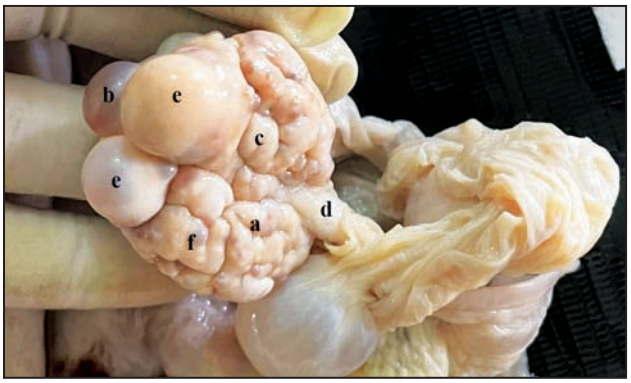

Fig 7. Right ovary of she-camel. a. Right Ovary, b. Large raised follicle (pyriform), c. Corpus albicans, d. Hilus of ovary, e. Regressing Corpus Leutium (pyriform) and f. Small growing follicle.

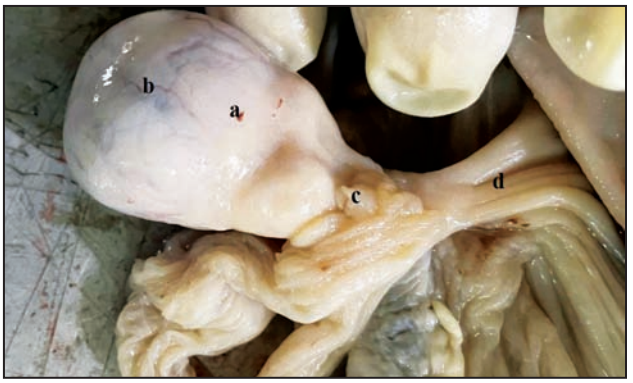

Fig 8. Left ovary of she-camel with CL in Pregnant Animal. a. Pyriform left ovary, b. Corpus luteum, c. Hilus of ovary and d. Ovarian ligament.

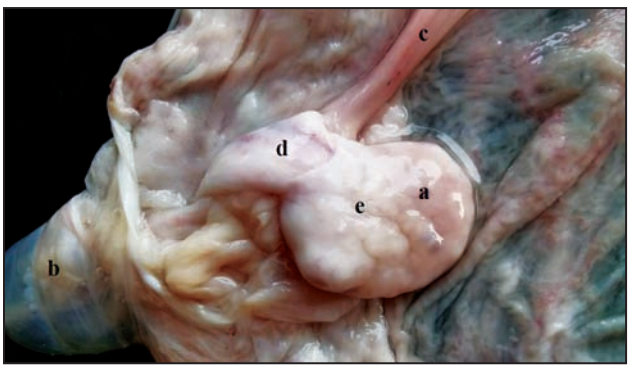

Fig 9. Left ovary of she-camel showing its lateral surface. a. Left Ovary, b. Bursa ovarica or Mesovarium c. Proper ligament of ovary, d. Hilus of ovary and e. Lateral surface of the ovary.

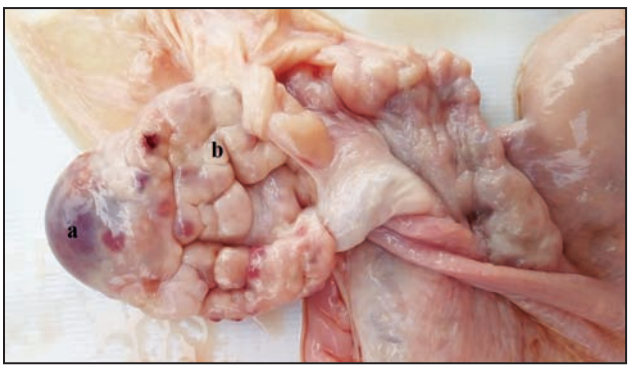

Fig 10. Ovary showing Graafian follicle. a. Graafian follicle and b. Corpus Albicans.

Dyce *et al* (2010) in domestic animals that each ovary was a solid, ellipsoidal body, though projections of big follicles from the surface and corpora lutea can make it uneven. Contrarily, Jarrar and Faye (2015) in camel found that the size of the left and right ovaries was the same. The ovary of older she-camels gets increasingly irregular and lobulated shape. The appearance and size of the ovaries differ depending on the animal's age and activity level. The left ovary was found somewhat larger in both length and width than the right one in present study, which was not reported earlier in camel.Both ovaries also had the corpus albicanus, which was seen there in varying numbers, sizes, and colours of white or grey (Fig 6, 7 and 8).

The mature CL in the left ovary was a compact, spherical body with a centre of fibrous tissue. The left ovary CL was pyriformed and ranges in colour from dark pink to grey. Shape of the ovary was pears like due to the CL. While the right ovary had a regressing CL which was also pyriform shaped but creamy in colour. The CL was a flabby, soft, laterally compressed sphere that protruded entirely from the surface of the ovary. These findings were in partial harmony with the findings of Arthur *et al* (1985), according to which in camel the corpora albicantia, were cream-coloured and the main contour of the ovary was obscured by mature follicles and the current corpora lutea of the breeding season, giving the latter an exaggerated, lobular form (Fig 7, 8).

The size of the Graafian follicles was found 1.5 to 3.0 cm. The mature follicle were readily separated from the ovary as a discrete sphere by slight presure. These findings resembled to the findings of Arthur *et al* (1985) in camel. The mature follicle can easily be separated from the ovary as a discrete sphere by gentle pressure at its attachment (Fig 7, 10). The mature follicle had a vascular wall; the follicular fluid was first yellowish and then becomes red. The young CL had a central blood clot and was spherical, soft, and brownish in colour. Present findings partially resembled the findings of Novoa (1970), according to which the corpus luteum was a soft, flabby, laterally-compressed sphere in camel. But according to Dyce *et al* (2010) each ovary was a solid, ellipsoidal body, though projections of big follicles from the surface

Table 1. Morphometerical observations of Left and Right Ovary of female camel.

Srial no.	Left Ovary						Right Ovary					
	Weight (g)	Volume (ml)	Length (cm)	Width (cm)	Thickness (cm)	Circumferance (cm)	Weight (g)	Volume (ml)	Length (cm)	Width (cm)	Thickness (cm)	Circumferance (cm)
1.	25.00	23.50	4.00	3.00	2.00	10.00	20.00	18.50	3.50	3.00	2.00	8.50
2.	13.40	12.00	3.50	3.00	2.00	8.00	7.00	6.50	3.00	2.40	1.80	6.00
3.	11.50	10.60	3.20	3.00	2.00	7.80	8.10	7.50	3.00	2.50	1.80	6.00
4.	30.40	28.00	4.50	3.50	2.00	10.50	18.40	16.60	3.50	3.00	2.00	8.00
5.	28.10	27.00	4.20	3.20	2.00	10.20	11.00	12.50	3.20	2.80	2.00	7.00
6.	25.90	24.00	4.00	3.00	2.00	10.00	10.00	10.50	3.00	2.70	2.00	6.50
Mean	22.38	20.85	3.90	3.12	2.00	9.42	13.08	12.02	3.20	2.73	1.93	7.00
SD7.	94113762	7.606247	0.473286	0.20412415	0	1.19065808	5.35029594	4.82510794	0.244949	0.25033311	0.10327956	1.048809
SE3.	24195586	3.105238	0.193218	0.08333333	0	0.48608413	2.18424917	2.96984207	0.1	0.10219806	0.04221637	0.4228174

and corpora lutea can make it uneven in domestic animals (Fig 10, 7). The mature CL was a 2.6 cm in diameter, flesh-coloured, compact sphere with a central region of grey connective tissue. Older CL had a bluish-grey or greenish external appearance (Fig 10, 7).

The shape and size of the ovary varied with their CL and content of follicles. The left ovary measured 3.90 ± 0.47 cm in length, 3.12 ± 0.20 cm in width, 2.00 cm in thickness, 9.42 ± 1.19 cm in circumference, 22.38 ± 7.94 g in weight and 20.85 ± 7.61 ml in volume. The right ovary measures 3.20 ± 0.24cm in length, 2.73 ± 0.25 cm in width, 1.93 ± 0.10 cm in thickness, 7.00 ± 1.05 cm in circumference, 13.08 ± 5.35 g in weight and 12.02 ± 4.82 ml in volume. Whereas according to El-Wishy (1988) the ovary of camel was measured 26 mm (2.6 cm) in length, 22-40 mm (2.2-4 cm) in width and 5-9 mm (0.5-0.9 cm) in thickness. Ghazi (1981) observed that the ovary of camel was 2 cm in length and 1.5 cm in width. Skidmore and Adams (2003) found that the ovary varied from 2.6 - 6 cm in length, 2 - 4 cm in width and 0.5 - 0.9 cm in thickness and each ovary weights between 3 - 4 g in dromedaries and approximately 5 g in bactrians. Novoa (1970) found that the ovary was a flattened organ with a length between 2 and 5 cm in camels. Ismail (1987) stated in camel the average dimensions and weight of the ovary were 2-4 x 1.5-2.5 x 0.5-1 cm and 2-5 g, respectively (Table 1).

Conclusion

The left and right ovaries' structure and positioning of camels was studied. The ovaries were found suspended by the broad ligament near the lumbar vertebrae, with the left ovary typically more prominent and positioned ventrally compared to the right one. Both ovaries exhibited variations in size and appearance, influenced by age and reproductive activity. The left ovary was found larger and had mature corpus luteum, while the right ovary showed signs of regression. Detailed measurements revealed differences in size between the two ovaries.

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IMPACT OF FLUNIXIN MEGLUMINE, PHENYLBUTAZONE AND ELECTROACUPUNCTURE ON OCULAR PAIN AND CORNEAL WOUND HEALING IN THE DROMEDARY CAMEL (*Camelus dromedarius*)

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ABSTRACT

This study aimed to determine the effects of flunixin meglumine, phenylbutazone, and electroacupuncture on corneal wound healing and pain relief in dromedary camels (*Camelus dromedarius*). The present study was conducted on sixteen dromedary camels (seven males and nine females). The camels were diagnosed with new corneal injury after undergoing general and ophthalmic examinations. An ophthalmological examination was performed to determine the dimensions of the corneal wound using an ophthalmoscope and florescence test to determine the measurement of the corneal wound. The study involved categorising camels into four groups and administering local ointment (gentamicin) to all camels. Furthermore, individualised treatment protocols were implemented for each group. The first group served as the control and received no treatment. The second group was treated with the flunixin meglumine, while the third group was injected with the phenylbutazone. The fourth group received electroacupuncture treatment once daily for a duration of five days. A comprehensive ocular pain scoring system was used, which involved the assessment of eight different ocular parameters to evaluate the effectiveness of the treatments. The mean maximum ocular pain level score at 12 hours after a corneal wound in the control group represented a mild-moderate level of pain greater than the mean maximum ocular pain level score in the phenylbutazone group. The flunixin meglumine and electroacupuncture treatment groups showed the lowest cumulative pain scores of all treatments. Electroacupuncture has been found to be an effective treatment for ocular pain relief and expediting corneal wound healing in camels. Flunixin meglumine was found to be the most reliable option in relieving ocular pain comparing to phenylbutazone or Electroacupuncture.

Key words: Camel, corneal, electroacupuncture, eye, flunixin, phenylbutazone, pain, wound

Acupuncture therapy, which originated from traditional Chinese medicine (Dewey and Xie, 2021; Harrison and Churgin, 2022; Hu and Liu, 2020), involves the insertion of fine needles to specific points on the body (Wei *et al,* 2020) to re-establish the homeostasis of the main organs by modulating the flow of blood and energy through the meridians (Matos *et al,* 2021). In humans, acupuncture can be useful in the treatment of many ailments, including ophthalmic conditions such as dry eye, myopia, paralytic strabismus, retinitis pigmentosa, optic atrophy, iritis, conjunctivitis, cataracts (Na *et al,* 2021; Nepp *et al,* 2002; Roy, 1980; Xu and Jin, 2021).

Many studies have also demonstrated the role of acupuncture in relieving pain. It has been proposed that acupuncture causes the release of endogenous opioid-like substances and activation of the diffuse noxious inhibitory control system mainly via neurotransmission modulation on the adrenergic, serotonin, and glutamate receptors in the central nervous system (Li *et al,* 2023; Makra *et al,* 2021).

Although acupuncture is used widely in many species, little scientific research has thus far documented the use of acupuncture techniques in camels, either for ophthalmic conditions or pain relief. Ocular trauma and corneal ulcers are more common in camels than other species and result in varying degrees of ocular pain as their eyes are in the lateral position and permanently prominent, optimizing vision (Gebreyohanes and Assen, 2017;

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Kumar *et al,* 2016). Camels are susceptible to eye injuries because they obtain food from trees and thorny weeds, which can cause corneal wounds and injuries to the ocular surface (Farouk *et al,* 2022; Gahlot, 2000). Moreover, camels suffer from a wide range of ophthalmic affections, including corneal lacerations, corneal opacity, and descemetocele (Bishnoi and Gahlot, 2004; Shawaf and Hussen, 2023). Free sensory nerve endings are found at the wing cell level of the epithelium, which makes the cornea one of the most sensitive of all body tissues. Corneal damage results primarily in inflammatory pain, requiring the routine use of nonsteroidal anti-inflammatory drugs (NSAIDs) in addition to specific etiological treatment.

Non-steroidal anti-inflammatory drugs (NSAIDs) are frequently employed to manage ocular pain and facilitate corneal ulcer healing in camels. However, their clinical efficacy in treating these conditions has not been evaluated yet (Makra *et al,* 2021). However, adverse events related to the administration of ophthalmic NSAIDs, including burning and stinging, hyperemia of the conjunctiva, and contact dermatitis, have been reported (Calder *et al,* 2005; Gaynes and Fiscella, 2002).

This study is aimed to evaluate the effects of electroacupuncture (EA) as compared to systemic NSAID treatment, relatively new in veterinary practice (Dewey and Xie, 2021; Jiang *et al,* 2022; Leite Ferreira *et al,* 2022), on corneal wound healing and ocular pain in dromedary camels.

Materials and Methods

2.1 Ethical approval

The study was approved for research purposes by the Ethics Committee at King Faisal University in Saudi Arabia (Approval number: KFU-REC-2024-OCT-EA00010)

2.2 Animals and clinical examination

The present study was conducted between May 2022 and October, 2024 on 16 dromedary camels (seven males and nine females). Camels had a median age ±SEM of 7 ±4.5 years and a median weight ±SEM of 365 ±115 kg. All camels afflicted with ophthalmological ailments were chosen at random from those brought to the Veterinary Teaching Hospital, College of Veterinary Medicine, King Faisal University. General and ophthalmic examinations confirmed that the camels were affected with new corneal injury. After general examination to exclude camels with other health disorders except corneal injury, ophthalmological examination was performed to determine the dimensions of the corneal wound using ophthalmoscope and florescence test to determine the measurement of corneal wound. Camels with a corneal wound between 5 and 10 mm were enrolled in the present study. Corneal wounds in the camels were controlled using fluorescein dye stain (fluorescein sodium ophthalmic strips, Eickemeyer) during the treatment period (Fig 1A, B). Eight ocular parameters were used in the ocular pain scoring system. The corneal wound was defined as cured when fluorescein dye was no longer retained; treatments and pain scoring were discontinued for that camel. The corneal wound healing was determined by measuring the wound length (mm) using Image J software.

2.4 Treatment groups

Camels were divided into 4 groups (each group had 4 camels), and all camels were treated with local ointment (Gentamicin), in addition to special treatment for each group according to the study.

The first group was not treated (control) after creating the corneal wound, while the second group was treated with the NSAID flunixin meglumine (Finadyne®, MSD Animal Health) once a day for five days at a dose of 1.1 mg/kg, intravenously. The third group was injected with the NSAID phenylbutazone (phenylbutazone 20% ®, SPI, Saudi Arabia) at a dose of 2.2 mg/kg intravenously once a day for five days. EA treatment was applied to the fourth group once daily for 5 days.

In the current study, four local acupoints were used according to a previous study in equines (Makra *et al,* 2021). EA treatment was applied for 20 minutes to the GB1 (gall bladder meridian), BL1 (bladder meridian), ST1 (stomach meridian), and TH23 (triple heater meridian) points every 24 h until the lesion healed (Fig 2A, B). For EA, we used 0.25 mm x 30 mm long Chinese steel needles (TEWA, Acupuncture needle) connected to an EA device (SDZ-II, Suzhou Medical Appliance Factory, China) at 4 acupuncture points around the eye (ST1, GB1, BL1, and TH23). A human "sensitive high frequency" protocol (recommended by the manufacturer for pain treatment in the human face) was used (80 Hz, 60 ms). The intensity gradually increased at the beginning until fine muscle fasciculation was noticed on the eyelid (20-30 mA), and this intensity was maintained for 20 minutes (Makra *et al,* 2021).

2.5 Pain scoring

For the ocular pain scores in camels, a scoring system designed for horses (Makra *et al,* 2021) was

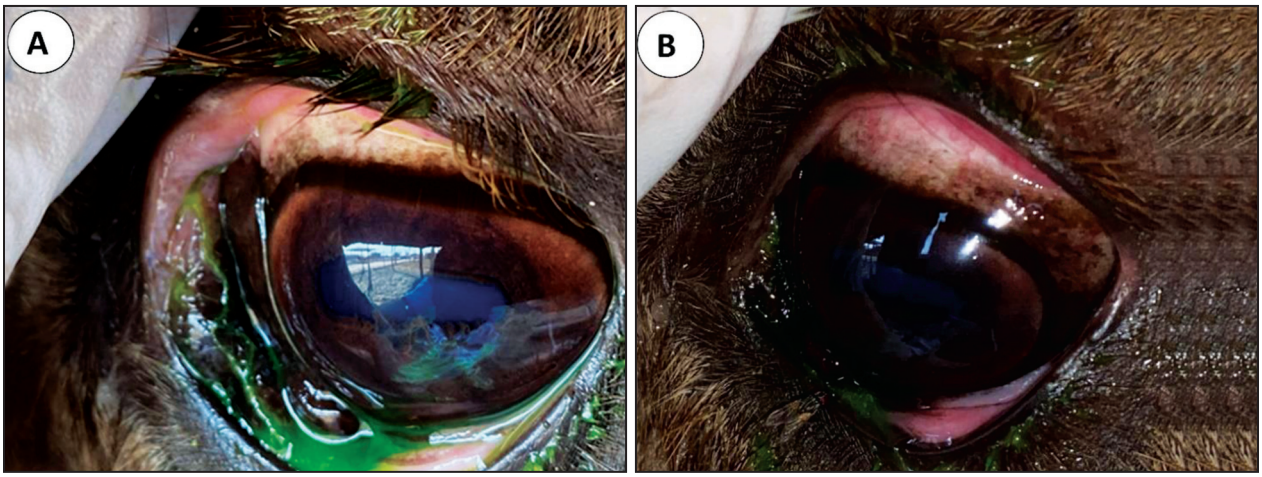

Fig 1. **A:** Corneal wound in camel were controlled using stained with fluorescein dye during the treatment period; **B:** Corneal wound in the same camel after treatment showed negative result for staining using fluorescein dye.

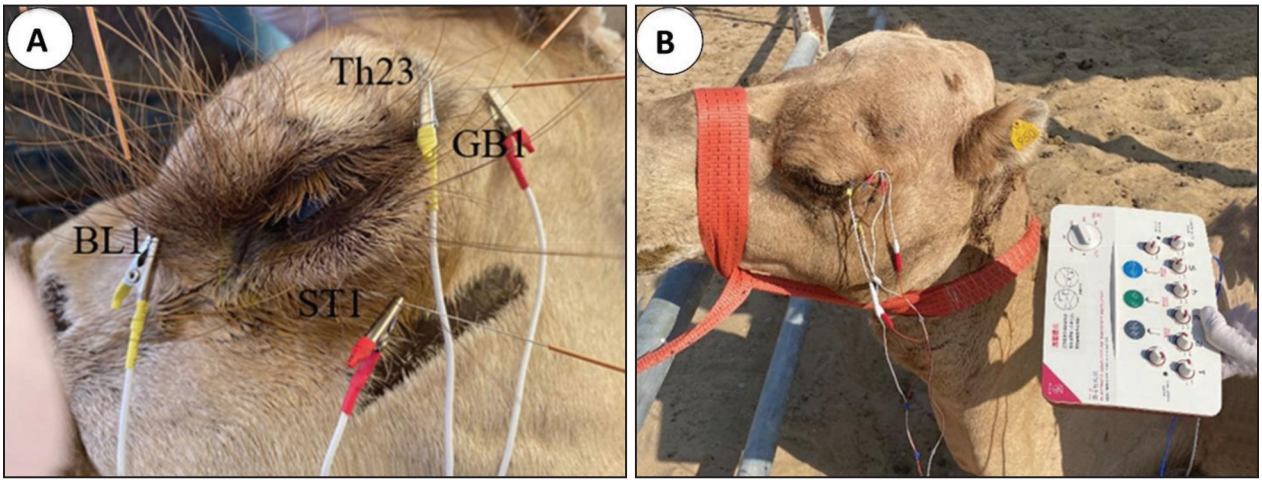

Fig 2. **A:** Electroacupuncture (EA) treatment in camel affected with corneal wound showed the acupuncture points: GB1 (gall bladder meridian), BL1 (bladder meridian), ST1 (stomach meridian), and TH23 (triple heater meridian) points; **B:** shows the treatment procedure using an electroacupuncture device and connecting wires to acupuncture points around the eye.

modified to incorporate ocular pain points in cattle (Dewell *et al,* 2014). Eight parameters were used in the ocular pain scoring system: corneal touch threshold, response to palpation of the adnexa, blepharospasm, photophobia, tearing (epiphora), eyelid swelling, corneal opacity and conjunctival hyperemia (Table 1). The pain of all camels was scored after corneal healing to establish baseline parameters (T0). Pain scoring points were recorded by two independent observers every four hours in the first 24 hours (0, 4, 8, 12, 16, 20 and 24 hours) postoperatively (T0 to T6), then twice daily through the fifth day (T7 to T16). The intensity of ocular signs was graded on a scale (0: normal, 1: mild, 2: moderate, and 3: severe) (Table 1).

2.5 Statistical analysis

The average pain scores for blepharospasm, tearing, eyelid swelling, corneal opacity, conjunctival hyperemia, and chemosis were calculated for various time points and graphed as a function of time. Corneal wound length was analysed with a two-way repeated-measure ANOVA and Bonferroni's test for multiple comparisons with significance set at $p < 0.05$.

Results

The selection process for the camels with corneal wounds was challenging due to the limited availability of cases that matched in wound dimensions and quality. Nevertheless, we were able to select cases with similar wound dimensions and fresh injuries that were less than a day old. Average changes in ocular pain scores over time were calculated for all eight parameters at various time intervals for each group, and the results were combined according to treatment groups (Fig 3).

Fig 4A shows the mean corneal wound healing in each treatment group over time. Fig 4B shows the changes in mean pain scores over time are illustrated in. ocular pain scoring started at 0 hours (T1) and ended at 144 hours (T16). Generally, the mean total Ocular pain scores decreased appreciably by the end of the study (T16, 144 hours). The mean maximum ocular pain score, representing a mild-moderate level of pain, reached 21.75 points in the control group 12 hours after corneal injury, while the mean maximum ocular pain score reached 21 points in the phenylbutazone group, 20.75 in the EA group, and 20 in the flunixin meglumine group. The mean ocular pain score after 24 hours had decreased in the camels treated with flunixin meglumine and EA to 17.5 points, and the control group scores were nearly equal to the phenylbutazone group with 19.5 and 19 points, respectively. The study found that administration of flunixin meglumine resulted in the lowest mean ocular pain score (11.25 points) after 48 hours of treatment, followed by the EA group with 13.5 points. On the fourth day, it was noted that the mean ocular pain decreased in the EA group (score 9.5) more than all other groups, while the flunixin meglumine treatment group score was 11, the phenylbutazone group was 13.5 and the control group was 13.75.

Table 1. Detailed ocular scoring system points for studied camels.

Ocular Score Parameter	Criteria	Points
Central corneal touch threshold	Normal compared with the initial value (increase <10%)	0
	11%-30% increase	1
	30%-50% increase	2
	>50% increase	3
Response to palpation of adnexa	No reaction	0
	Mild reaction or reaction to subsequent palpation	1
	Pull the head immediately away	2
	Violent reaction, avoidance behavior	3
Blepharospasm	Lids are completely open, in normal position	0
	Lids are partially closed, <50%	1
	Lids are partially closed, >50%	2
	Lids are completely closed	3
Photophobia	No intolerance to a bright light	0
	Partial intolerance to a bright light, <50%	1
	Partial intolerance to a bright light, >50%	2
	Full intolerance to a bright light	3
Tearing (epiphora)	No tearing	0
	Mild tearing	1
	Moderate tearing	2
	Marked tearing	3
Eyelid swelling	No swelling	0
	Mild swelling	1
	Moderate swelling	2
	Marked swelling	3
Corneal opacity/edema	No opacity	0
	Lesional or perilesional mild opacity	1
	Moderate opacity	2
	Complete corneal opacity	3
Conjunctival hyperemia/chemosis	Normal pink	0
	Mild injection	1
	Moderate injection, chemosis	2
	Marked hyperemia, chemosis	3

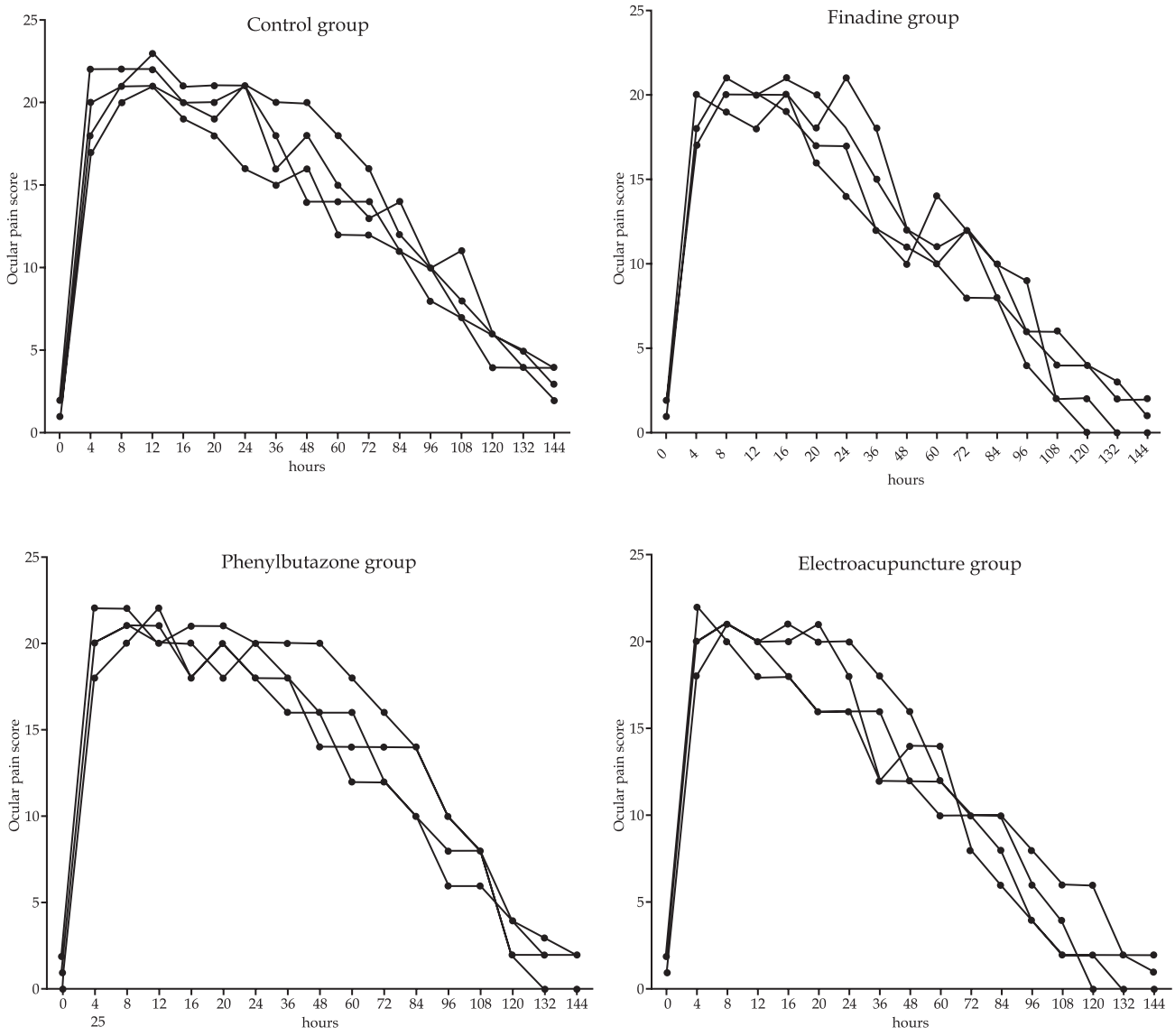

Fig 3. Mean ocular pain scores over time for all eight parameters at various time points for each group.

All corneal wounds were healed, as noted by negative fluorescein uptake, within an average of seven days. None of the eyes became infected or demonstrated any other severe complication. Despite a negative fluorescein test result for corneal wounds in most groups after the seventh day post-injury, some ocular signs such as opacity, corneal scars, and blepharospasms persisted in the treated eye for more than another seven days. It was also noted that the flunixin meglumine treatment group had faster corneal wound healing than the rest of the groups. The speed of corneal wound healing in the EA group was faster than in the phenylbutazone and control groups. There was a positive correlation between corneal wound healing and the ocular pain score in all groups.

Discussion

Acupuncture theory suggests that many acupuncture points are suitable to treat ocular pain and corneal wounds, including systemic and local points (Cariello *et al,* 2006). The main use of acupuncture in medical therapy is based on its analgesic and anti-inflammatory effects (Parmen *et al,* 2014). Due to the lack of information on the use of Chinese acupuncture in camels, the target points for electroacupuncture in the present study were selected based on previous studies conducted in cattle (Kim *et al,* 2004) and horses (Makra *et al,* 2021) with some modification in acupuncture needle placement due to the anatomical differences around the camel eye. Data in this study demonstrated that peak pain levels persisted for up to 24 hours in most treated groups.

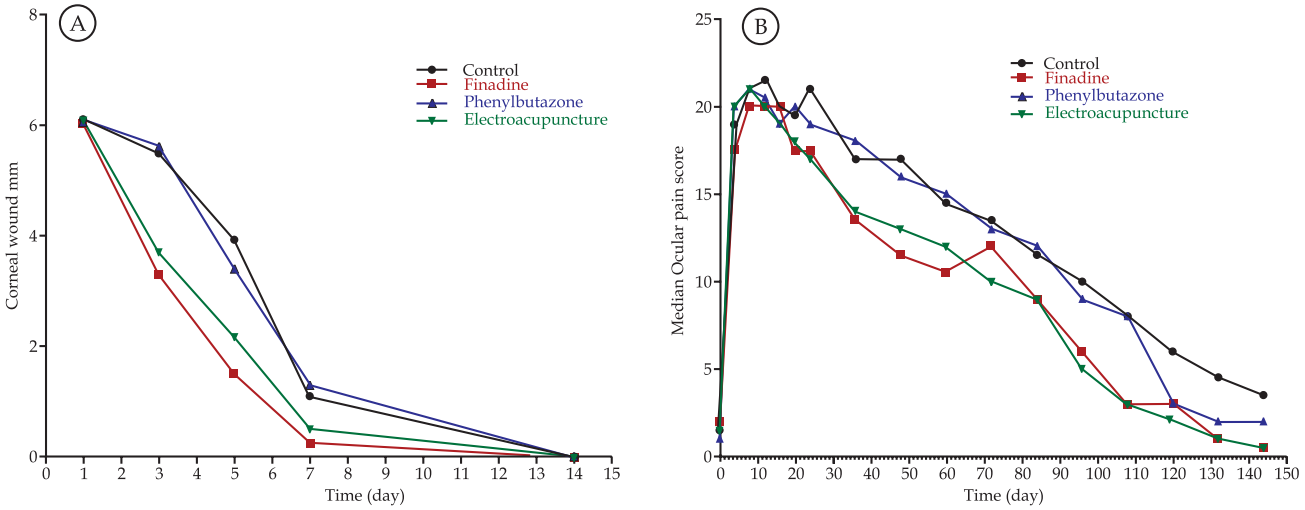

Fig 4. **A:** The Mean corneal wound healing (mm) of treatment groups over time; **B:** Mean total pain scores for all treatment groups over time.

These findings provided additional information about peak pain levels and pain persistence in ocular disorders in dromedary camels. The decreased peak pain after administration of the flunixin meglumine and phenylbutazone compared to the control group was consistent with previous studies in humans treated with oral NSAIDs after keratectomy (Ripa *et al,* 2020). Our observations indicate significant improvements in the condition of camels treated with NSAIDs, with reduced ocular pain evident after 72 hours of initiating the treatment. These findings are consistent with previous studies (Galera and Brooks, 2012; Hong *et al,* 2014; Singer *et al,* 2015). This pain persistence is longer than that observed by Sobas *et al* (2017), who reported a significant decrease in ocular pain score after 24 hours in humans. In dogs, a significant decrease in pain occurred after 48 hours (Clark *et al,* 2011; Dewey and Xie, 2021; Jiang *et al,* 2022).

The response to central corneal touch threshold palpation in the present study varied substantially over time, consistent with previous observations in bovine calves (Dewell *et al,* 2014). However, in the same calf study, no association between corneal wound healing and corneal touch threshold parameters was observed.

Blepharospasm in the present study varied the most of all pain and healing parameters in each camel and demonstrated a similar trend to pain severity over time. Similar results were reported in cattle and horses previously (Dewell *et al,* 2014; Makra *et al,* 2021). Blepharospasms were also previously observed as the most predominant sign of pain in dromedary camels with eyelid disorders and ocular discharge (Abdella *et al,* 2018). For many ocular pain parameter scores in horses, Makra *et al* (2021) reported that only blepharospasm was most consistently correlated with pain.

The tearing parameter in the current study may vary by climate, and camel eyes are generally very wet and full of tears (Am *et al,* 2018). The tearing score in the present study did not reflect the degree of pain in camels due to the absence of significant difference among treated groups. Tearing continued at a high level until 48 hours post-injury remained mild or moderate until the end of the experiment and has been observed to continue even when camel corneal wounds healed completely.

Corneal opacity was reported in dromedary camels and considered as an important sign of corneal ulceration (Abdella *et al,* 2018; Kumar *et al,* 2016). Nassaralla *et al* (1995) reported reduced corneal opacity after NSAID treatment in rabbits affected with corneal damage, which is in consistent with the present study results. The administration of EA in camels was more effective in reducing corneal opacity after injury compared to the no-treatment control and phenylbutazone groups, in which corneal opacity clearly persisted until the fourth day. Cariello *et al* (2006) also reported the positive effect of EA treatment on corneal opacity in rabbits.

In the present work, corneal wound healing was observed at the end of the first week post-injury in most groups, even in control camels which was consistent in equine observed by Makra *et al* (2021) and Raghunathan *et al* (2017), who evaluated the speed of corneal wound healing. The healing speed of corneal wounds in camels treated with flunixin

meglumine or phenylbutazone was faster than that of the untreated group; similar results for NSAIDs in ocular disorders were reported previously (Singer *et al,* 2015; Ting and Ghosh, 2019). Most previous studies highlighted the importance of using NSAIDs through systemic injection and avoiding using them through local use in the eye. Systemic administration prevents local side effects on the ocular surface that might delay the healing of corneal wounds and directly damage the anterior part of the eye (Hong *et al,* 2014; Ripa *et al,* 2020). Previous studies have also noted that long-term use of anti-inflammatories may cause serious gastrointestinal, hepatic and renal side effects (Fayez *et al,* 2023; Fernandez *et al,* 2019; Monteiro-Steagall *et al,* 2013). The speed of corneal wound healing in camels treated with EA in present study was faster than in the group of camels treated with phenylbutazone. Makra *et al* (2021) investigated the EA technique in ocular disorders in horses. EA also demonstrated a significant improvement in corneal injury in rats (Yang *et al,* 2022).

In conclusion, our data provide important information on ocular pain management in dromedary camels. Flunixin meglumine is more reliable in relieving ocular pain than phenylbutazone or EA. All treatments were more effective than the no-treatment control in relieving ocular pain and hastening the recovery from corneal wounds. The data we have collected will serve as a valuable resource for conducting further research on the efficacy of EA therapy for managing ocular pain and promoting corneal wound healing in dromedary camels and other animal species.

Acknowledgements

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Conflicts of interest

None

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RUMINOSCOPIC VISUALISATION OF AN UNUSUAL RUMENITIS IN A SIX-MONTH CAMEL CALF: A CLINICAL CASE REPORT

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ABSTRACT

The present clinical case report aimed to describe a novel ruminal finding in a 6 months camel calf. The case was suffering from chronically progressive weight loss, unthriftiness and stunted growth. Upon clinical examination, the calf appeared with generalised weakness, the origin of which couldn't be clinically detected. A comprehensive clinical and laboratory examination was performed but it did not yield a diagnostic significance. Examination of the rumen *via* endoscopy revealed presence of massive lesions occupying the caudo-dorsal parts of the rumen. The nature of the reported lesions was extensive scare tissue formation, ulceration, ruminal wall hypremia, thickening of ruminal wall and nodules formation.

Key words: Camel, rumen, ruminoscopy, endoscopy, rumenitis

Digestive disorders in camels are highly prevalent and represent a major concern in camel medicine (Cebra, 2014). These include those occupying the oral cavity, oesophagus, rumen and intestine. Each of these organs can sometimes have slightly varying clinical presentation and should be approached using specific diagnostic tools. The diseases affecting the oral cavity can be approached simply by direct inspection of the oral mucosa (Eze *et al,* 2012), whereas the vast majority of oesophageal disorders in camels manifest clinically with vomiting following swallowing and are approached via oesophagoscopy (Shawaf *et al,* 2017; Zabady and Shawaf, 2022). On the other hand, enteric diseases may sometimes appear clinically with diarrhoea, constipation or eventually progressive unthriftiness in neglected chronic cases. Intestinal abnormalities are best assessed by abdominal ultrasound (Tharwat, 2020).

Although, abdominal disorders may appear with variable forms of abdominal distention (left or right sided or even symmetrical) (Tharwat *et al,* 2012), there are some disorders (such as those affecting the dynamics of ruminal wall) that do not always have obvious clinical presentation especially in the early course of the disease, rendering clinicians from reaching accurate diagnosis and making disease identification a challenging task. Such cases requires collaborative efforts made among specialised clinicians and could be best approached through the application of comprehensive diagnostic tests and sophisticated veterinary imaging.

An example of ruminal disorder that primarily affects the ruminal wall integrity is gastric ulceration. Ulcerative lesions of the ruminal mucosa could be classified as either perforating or non-perforating ulcers (Neubert *et al,* 2024). Additionally, the vast majority of perforating gastric ulcers appear with severe clinical presentation when compared to the non-perforating type, with the former group carrying the possibility of invading other organs within the abdomen such as the kidneys or peritoneum, or within the thorax and leading to pneumonia, eventually resulting in potential multi-organs dysfunction (Neubert *et al,* 2024). In some cases of perforating gastric ulcers, the ongoing blood loss resulting from damaged gastric vasculatures might also lead to chronic, progressive and unresponsive anaemia, which could be severe enough to cause death (Wagener *et al,* 2023).

The purpose of this work was to report an unusual necrotic lesions in the ruminal wall of a young dromedary camel calf. The novelty in this work is related to the successful ante mortem ruminoscopic detection of such rare finding as well as to report the associated clinical signs. In addition, the possible

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theories behind the aetiology for such lesions are also thoroughly proposed and critically discussed.

Materials and Methods

The persent case report was approved by the Research Ethics Committee at King Faisal University (KFU-REC-2024-DEC-ETHICS2917). A six-months she-camel calf of Waddah breed weighing 110 Kg was admitted to the Veterinary Teaching Hospital at King Faisal University with a complaint of stunted growth, lack of vitality among other camels, isolation from the herd and unthriftiness. The case had been examined by some local veterinarians who, at that time, provided a panel of commercially available medications (broad spectrum antibiotic, anti-inflammatory, multivitamins, rumenatorics and nerve tonic), which was used with little transitory effect or no satisfactory response to therapy. Upon arrival to the camel clinic, the case was clinically examined and vital signs were thoroughly assessed. All vital signs were within the normal range except for apparent weakness and slight dullness. Examination of the skin and wool revealed presence of circular-shaped alopecia suggestive of possible fungal lesions (Fig 1). Therefore, we then voted for ruminoscopy for examination of possible ruminal foreign body because the case did not have a specific clinical presentation indicating specific organ involvement. The details of ruminoscopy procedure application in camel is described entirely elsewhere (submitted for publication) and a brief summary is recapitulated in this paper. The ruminoscopic procedure was performed while the animal placed on sternal recumbency. Then an intravenous dose of sedation was used to control the animal and to minimise any potential physical damage to the endoscope. Once sedated, a wooden mouth gag was then placed inside the oral cavity and was securely handled by two expert clinicians. After ensuring the patency of the oral cavity, the endoscope was then inserted *via* the oral route and passed the pharynx and eventually reached the oesophagus. At this point, the head and neck of the animal were lowered to a position below the trunk to facilitate drainage of any lodged food or accumulated saliva. Adopting and maintaining the animal in this position enabled easy and clear visualisation of the oesophagus as the endoscopy was passing toward the cardia opening. Finally, the insertion tube of the endoscopy was pointed toward the cardia opening and advanced through it and the rumen was then accessed. The rumen was endoscopically visualised thoroughly and the ruminal lesions were also detected and described. In addition, the strength of ruminal wall motility and the nature of ruminal contents were also assessed. Haematological finding included neutrophilia, lymphocytopaenia and reduction in RBCs count and haemoglobin level.

Results and Discussion

The endoscopic examination of the rumen enabled visualisation of an unusual ulcerative and necrotic lesions that were mainly visible in the caudal border of the ruminal wall (Fig 2A), with the possibility that the lesions were initially started in the ventral floor of the rumen and then developed and spread caudo-dorsally. A small part of the dorsal roof of the ruminal wall was found abnormally pedunculated (Fig 2B), although this region did not show similar necrotic lesions, but it was evidently having abnormal morphology suggestive of underlying disease process. Interspersed within the necrotic tissues were some regions showing round-shaped nodules like structures arising from the ruminal wall with no visible discolouration or tissue degeneration (Fig 2C). The regions of junctions between healthy and necrotic tissue appeared having red (ulcerative) line demarcating damaged from non-damaged tissues (Fig 2D). Evidence of ruminal wall blood vessels congestion was also found in regions in close vicinity to the necrotic lesions (Fig 2E). The visible part of the necrotic lesions appeared black and greyish in colour with some patchy foci having whitish and yellowish discolourations (Fig 2F). According to previous clinical experience, the motility of the ruminal wall in this case was not as strong as we had usually observed in otherwise apparently healthy camel calves. The content of the rumen was

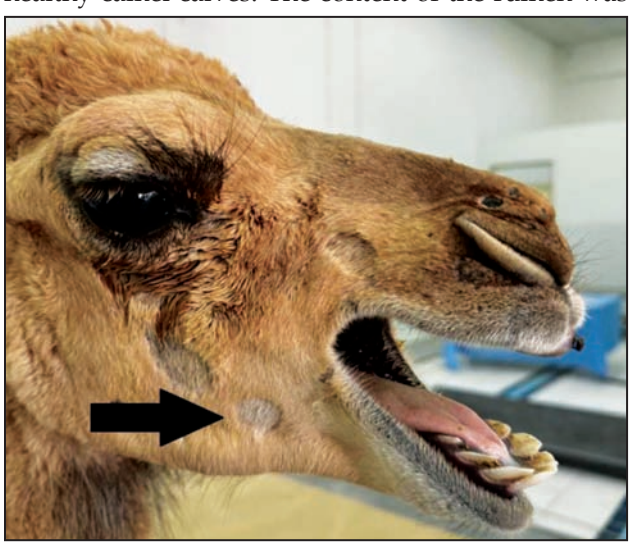

Fig 1. The camel calf appearing with some patches of circular-shaped alopecia (indicated by arrow) in the head region.

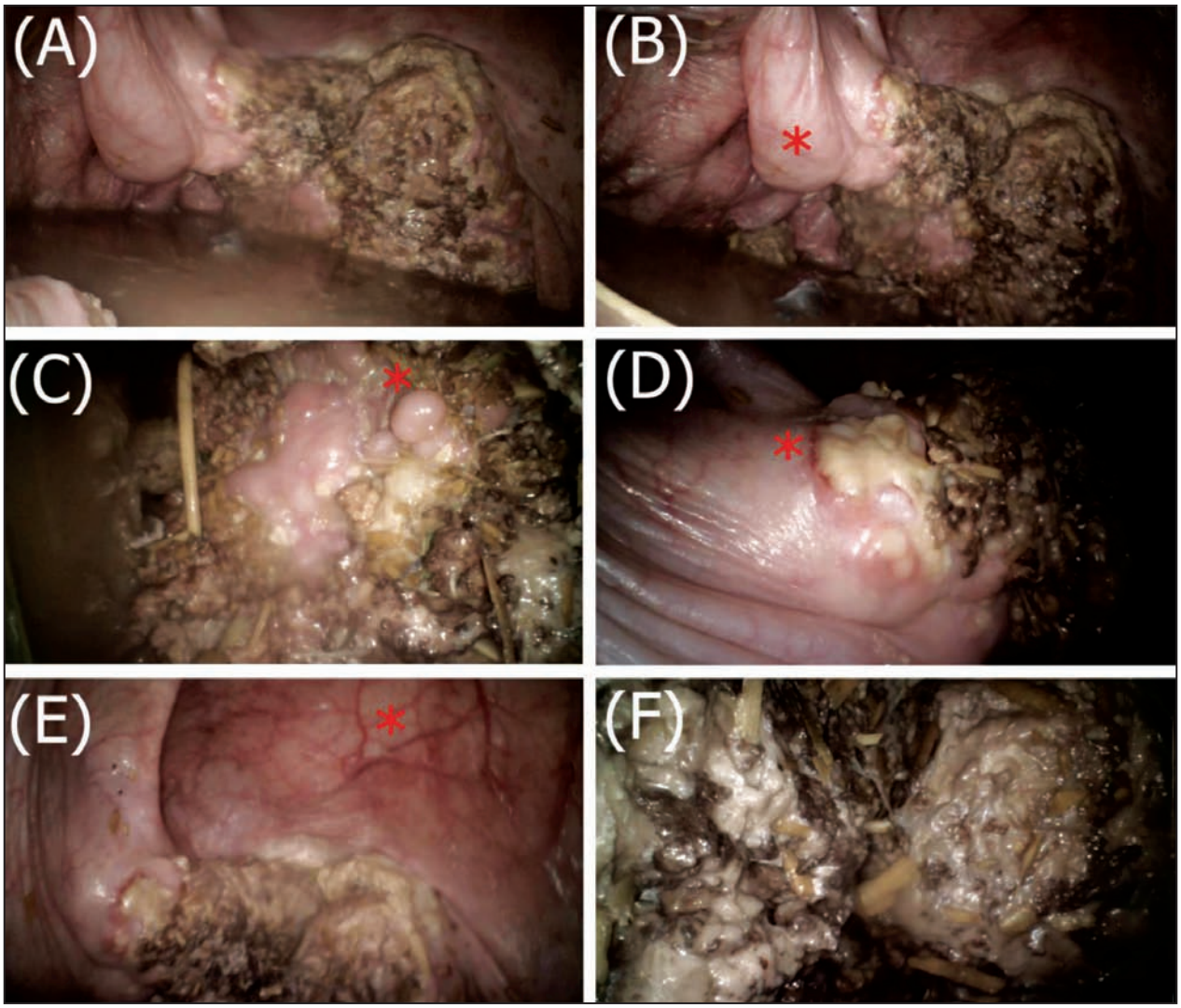

Fig 2. Ruminoscopic appearance of the ruminal wall in a six-months camel calf showing the associated lesions of necrosis. Fig A shows the overall appearance of the lesions in the caudal part of the rumen (red star). Fig B reveals a pedunculated ruminal wall (red star). Fig C shows some vacuoles (red star) adjacent to necrotic tissues. Fig D reveals a red line separating healthy and non-healthy tissues (red star). Fig E reveals visible congested blood vessels (red star). Fig F is a close view to the necrotic tissues.

found entirely fluidly and looked stagnant in nature and appeared greyish in colour. No obvious change in ruminal wall colouration was noted in the rest of the rumen.

Improving the diagnostic accuracy and disease detection capability, especially in camel medicine, has now become a necessity for advancing the welfare of camels. Camels have the capability of carrying some diseases without exhibiting a clear and specific clinical picture. Nevertheless, this characteristic might pose a challenge to clinicians because the clinical signs that could have been suggestive of disease involvement or organ dysfunction are hidden by the diseased camel. In 2018, another report was published on a Bactrian camel that had been presented clinically with lethargy and progressive loss of body conditions over a month (Heck *et al,* 2018).

The most commonly encountered ruminal disorder in farm animals is rumen acidosis, which is routinely diagnosed through the measurement of ruminal juice pH (a pH of less than 5 is indicative of rumen acidosis) (Golder and Lean, 2024). The corrosive action of the lactic acid on the ruminal wall in such cases usually results in necrosis and death of rumen papillae and eventually leads to black discolouration of rumen interior (Voulgarakis *et al,* 2023). However, this feature is used diagnostically in post-mortem examination (Kumar *et al,* 2019). In a previous study, the black discolouration of the ruminal mucosa had been visualised during

ante-mortem examination through the application of ruminoscopy in 110 cattle suffering acute lactic acidosis (Sasikala *et al,* 2018). In the present case, on the contrary, these lesions were not seen in the examined camel calf and therefore it is unlikely that one camel that was affected by ruminal acidosis. Additionally, it is not expected in camels with ruminal acidosis to observe ulcerative lesions and scar tissue formation occupying only the caudo-dorsal part of the rumen.

Our results indicated that the nature of the lesions are hypremic in junctional regions between healthy and not healthy tissue, this feature might indicate ongoing inflammation in process of spreading. On the other hand, the scar tissue formation that represents the majority of the detected lesions may reflect the chronicity of disease course. The fact that the case was a 6-months old, when was presented to the clinic with such chronic condition, might suggest that the lesions could have started when the calf was in neonatal period and developed over time.

Since clinical ruminoscopy has not been extensively employed in dromedary camel, therefore our findings were assessed on the light of available pathological literature in llama and alpaca or in other animal species. A comparable lesions of gastritis was found on post-mortem examination of a camel that had been initially suffering from non-digestive abnormalities (Wellehan *et al,* 2004). In this report, Gross pathological examination of the rumen revealed presence of granular, irregular and thickened mucosal surface. In this paper, the camel died and was subjected to post-mortem examination which similarly revealed presence of swollen ruminal wall having multifocal yellowish and irregular masses with some intermixed whitish tissues. Such an infection is frequently caused by an aquatic oomycete in the horse and dog (Martins *et al,* 2012). The clinical appearance of fungal alopecia in the head might indicate that the calf was raised in an environment promoting fungal growth. Nonetheless, the current case is reported as idiopathic ruminitis and further research is required in the future when similar lesions are identified via ruminoscopy.

In conclusion, the ruminoscopic detection of such lesion is still clinically useful and should be taken into account for future clinical settings guiding clinicians for better differential diagnosis of diseases affecting the digestive system of camel. However the correct causative agent or infection need to be established.

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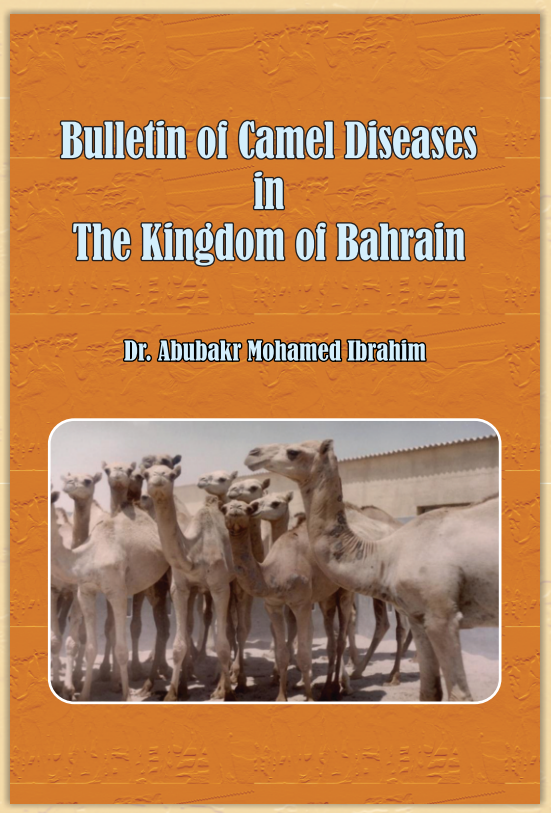
Bulletin of Camel Diseases in The Kingdom of Bahrain

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

About the Author

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



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MY JOURNEY TO CAMEL SCIENCE TO BECOME A CAMELOLOGIST?

Bernard Faye
International Camel Expertise, Montpellier (France)

My discovery of the camel

Probably, I saw my first camel in a circus in my native town in France, but I really discovered the dromedary in Ethiopia for first time as "tropicalist veterinarian" in Africa in 1975, then in Niger where the camel is an emblematic animal of the Tuareg pastoralists. During my stay in Niger (1977-1979), I worked within the framework of the French cooperation on the "Livestock Reconstruction" programme, a project following the great drought of 1973-1974 which had seen nearly half of the national livestock perish. This programme was based on two main activities: firstly, the establishment of a network of "ranches for livestock multiplication", aiming to develop a "rational management" of herds in order to obtain a large number of animals quickly, and secondly, to distribute the animals to the affected herders through an advantageous credit system based on deferred repayment in cash or in animals issued from loaned herd. In this issue, Tuareg breeders preferred to get 5 camels rather than 5 cows or even 10 sheep or goats.

But, my first discover of camel as young scientist was during my second stay in Ethiopia (1980-1983). In the Rift Valley, a mythical place in the world's geology, sheep, goats and sometimes cattle were widely affected by a disease (called "*degamaka*" by Afar pastoralist), characterised by difficult gait, then inability to stand up, and often by the death. After some investigations, I was able to make a diagnosis: a secondary copper deficiency provoking the famous "sway-back", secondary because linked to the excess of sulphur and molybdenum (two antagonists of copper) in grasses growing in the volcanic soils of the Rift Valley. However, the camel, widely present in the area, seemed to make a mockery of this situation, and in the blood samples I collected on the fourth species (cattle, sheep, goat and camel), plasma copper in camel only was in normal values (Faye *et al,* 1991). To understand, this difference between species, I started my first investigation on camel feeding behaviour by following a camel herd for a week during the dry season, then again during the rainy season, sleeping in nomadic camp, drinking only camel milk and accompanying the shepherds in the field. At this occasion, I discovered that camel appreciates diversified plants and through its feeding behaviour, takes two or three times more plant species than its herbivorous colleagues, at all levels, from the grass to the top of thorny trees (Faye and Tisserand, 1989). It is well known that diversity is a guarantee of a better balanced diet.

The mineral and water metabolism in camel

After Ethiopia, joining French Research Institute (INRA, then CIRAD), I started a long collaboration in Morocco with my colleague Mohammed Bengoumi at the Agro-Veterinary Institute at Rabat and the physiology lab at Casablanca University, on the mineral and water metabolism in camel. We wanted to understand the physiology of camel resistance to poor nutritive food and to dehydration. With my Moroccan colleagues, we made several discoveries: the camel is able to control deficit situations, to store better in its organs, to manage the metallo-enzymes as glutathione-peroxidase, sodium oxide-dismutase or ceruloplasmin, to save losses, to reduce its metabolism if necessary (Faye and Bengoumi, 1997; Bengoumi *et al,* 1998 and 1999; Essamadi *et al,* 1998; Faye *et al,* 1999). These investigations on mineral metabolism were prolonged later in Emirates, in the frame of a PhDon selenium (Seboussi *et al,* 2008 and 2009) leading to a review on selenium metabolism and the recommendations on selenium supplementation in camel (Faye and Seboussi, 2009). More recently, several investigations were achieved in Saudi Arabia in the frame of FAO project (2010-2015), on mineral supplementation notably using organic selenium (Faye *et al,* 2014a), then in collaboration with King Saud University, on trace mineral status of organ's camel as liver or kidneys (Abdelrahman *et al,* 2022).

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Clinical and nutritional biochemistry

However, my interest was not limited to minerals. Other blood parameters were investigated since my first investigations in Ethiopia and Djibouti (Faye and Mulato, 1991) or in Morocco (Bengoumi *et al,* 1999) and later in Saudi Arabia, notably the sexual hormones (Al-Saiady *et al,* 2014). Other researches were achieved in collaboration with the university of Casablanca on the blood indicators of stress on camel (El-Khasmi *et al,* 2015), calcium and phosphorus metabolism (El-Khasmi and Faye, 2011), notably the role of vitamin D (El-Khasmi and Faye, 2019). Naturally, my contributions to many studies on haematology and clinical or nutritional parameters in blood, but also in organs (Faye *et al,* 2013) led to the publication of a book by Springer on "Camel haematology and Clinical Biochemistry" (Faye and Bengoumi, 2018).

The mystery of the hump

Camel always bring surprises about his ability to be satisfied with the little that the environment gives him, and especially to manage his fat storage he has on his back. Contrary to a preposterous idea that is lying around in some popular books, the hump is not water storage, but a big amount of adipocytes, and this storage evolves according to the status of the animal (Faye *et al,* 2001a). So, I investigated the hump, to understand its rate of decrease or increase, its links with breeds, nutritional status and the role of leptin hormone in its management (Delavaud *et al,* 2013). My interest for the hump management lead to set up a specific scoring of the camel body condition (Faye *et al,* 2001b) which was used worldwide.

The camel meat and milk

From the hump to the other parts of the camel body, I was naturally interested by camel meat and notably its composition by comparing Bactrian and dromedary meat in the frame of another PhD in collaboration with Prof. Kadim from Qaboos University in Oman (Raiymbek *et al,* 2015 and 2019). Additionally, I published several papers on the camel meat market, leading to the participation to the book "Camel Meat and Meat Products" (CAB publ.) proposed by Kadim *et al* (2013).

I had already tasted camel milk in Ethiopia in the Afar camps. The first time, I drank it from a calabash coated with fat with impurities floating around that I didn't want to know the origin! Then I drank it from the milking bucket in the farms in Turkmenistan, then later in pasteurised plastic bottles in the Emirates or Saudi Arabia. Finally, it was even accessible in milk cartons at the Nouakchott dairy in Mauritania or in glass bottle in the north of France! Thus began for me, the long saga of camel milk, the discovery of its virtues, its tonic functions, the particularities of its proteins (Ryskalieva *et al,* 2018), fatty acids (Konuspayeva *et al,* 2007 and 2008) and the richness of its vitamins (Faye *et al,* 2009). To listen to colleagues in Asian or African countries, camel milk proved the miracle product. Some of them claimed that it cures tuberculosis patients. Another claims that it has anti-diabetic and anti-cancer properties. There is always a little truth in it, but as scientific truths mix with legends, it is better to understand the secrets of its composition. So, I began to describe the complex chemistry of this white liquid notably by comparing the "one-hump" to the "two-humps" in a place where the two species coexist and interbreed, in Kazakhstan (Faye *et al,* 2008) and I contributed to another book regarding the health benefits of the camel products (Al-Haj *et al,* 2020). Finally, I tried to understand the links between milk composition and health effects (Faye and Konuspayeva, 2024), but also the risks linked to its potential contaminations by pesticides or heavy metals (Konuspayeva *et al,* 2011a and b) and the conditions to get organic milk (Konuspayeva *et al,* 2023a).

My adventure regarding camel cheese making began for me in Saudi Arabia in collaboration with Prof. Konuspayeva from Al-Farabi University in Kazakhstan (Konuspayeva *et al,* 2017) and continued by practical training of farmers and dairy technicians in Kazakhstan, Mongolia, Algeria, Morocco, Chad, Mauritania, Turkey and also in Spain and France. But another camel milk product retained our attention, the fermented camel milk which has strong probiotic effects. Thus, I contributed to research on this processed milk in Sudan (Ahmed *et al,* 2015) and in central Asia (Konuspayeva *et al,* 2023b), especially by the investigation of its microbiological flora (Baubekova *et al,* 2015).

The camel economy and demography

Being interested by the production, an additional question was "What is the economy of camel products ?". This question led to many investigations on the different camel farming systems in many countries from Africa (Biya *et al,* 2021), Middle-East (Abdallah and Faye, 2013) or India (Laval *et al,* 1998). The camel milk market is experiencing an important recent development (Ait-El-Alia *et al,* 2025), especially thanks to the progressive integration of camel milk producers into market (Faye and Corniaux, 2024), including the international market of milk powder (Konuspayeva *et al,* 2022). The camel

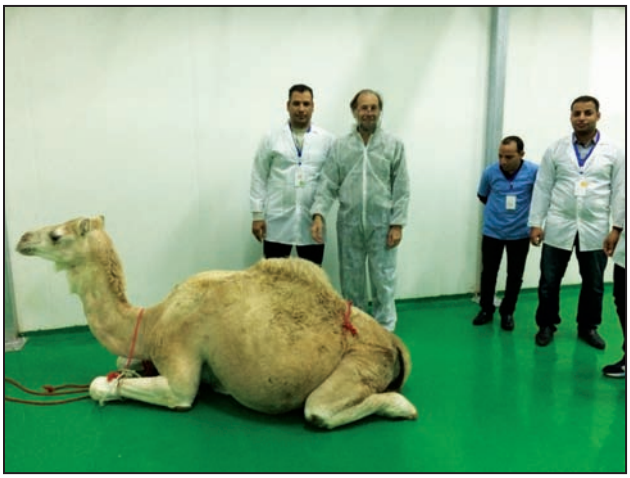

Fig 1. Practical demonstration at the Algerian Veterinary Conference at El-Oued, Algeria (2016).

Fig 2. Camel calving at the Camel Research Centre, Al-Jouf, Saudi Arabia (2011).

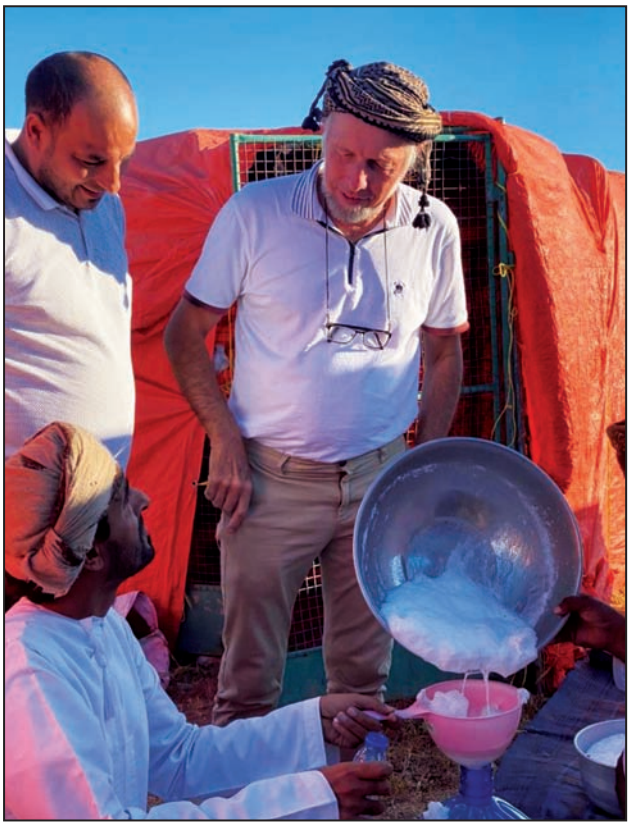

Fig 3. Training on milk hygiene of the camel farmers in Dhofar, Oman (2022)-FAO project on camel cheese.

Fig 4. Trials on camel embryo-transfer in Mauritanian Centre of Camel breeding development (CMDEC) supported by FAO, Nouakchott, Mauritania (2019).

milk value chain was also investigated in Saudi Arabia (Faye *et al,* 2014b) and in the frame of different development projects, in Chad, Mauritania, Mali, Niger. The question of the camel economy also refers to its demographic developments. For that, I tried to achieve a critical analysis of the current available data in FAO database (Faye, 2020) and to understand the impact of climatic changes on the camel farming systems and their geographical distribution worldwide (Faye *et al,* 2012). However, the camel economy is not limited to its national or international contribution, but it is important also to the household economy (Tardif *et al,* 2014).

Other contributions

The camel breeding requires to investigate several dimensions of the animal and its farming

Fig 5. With The Saudi delegation at the 4th Conference ISOCARD at Almaty, Kazakhstan (2015).

Fig 7. Restrained camel prepared for hump biopsy, Cholak-Korgan, Kazakhstan (2013).

practices. Thus, I was implied in many other studies including genetics (Al-Abri *et al,* 2019; Burger *et al,* 2019), welfare (Menchetti *et al,* 2021) leading notably to the scientific edition of the book "Dromedary Camel Behaviour and Welfare" (Padalino and Faye, 2024), feeding (Laameche *et al,* 2019), milking (Ayadi *et al,* 2016), veterinary sciences (El-Wathig and Faye, 2016; Gossner *et al,* 2016; Diall *et al,* 2022), ecology (Trabelsi *et al,* 2023) and even camel history (Faye *et al,* 2024) for citing few papers only.

Conclusion

There are few camels in my country, France. It is why I followed this animal and the people living with him in many other countries. Finally, I was seduced by the camel for three main reasons: he is an interesting biological model, he is a remarkable producers of milk and meat in harsh conditions and he is a fundamental element of the desert ecosystems. Globally, the camel is a quest for survival first, happiness perhaps, knowledge certainly. This is why, tirelessly weaving a network of passionate

Fig 6. Training on camel cheese making with farmers from Atyrau, Kazakhstan (2016).

researchers, I founded in 2006 with a few others, the International Society for Camel Research and Development (ISOCARD) in order to regularly bring together these researchers who are anxious to better understand this very special animal. And for a good cause, I invented a new discipline: "camelology" (Faye and Gahlot, 2024). By giving a definition of this new discipline in the website that I supervise in my former research Institute CIRAD (https://camelides.cirad.fr), I was even challenged by the French Academy who asked me the origin of this neologism of which I have claimed the authorship as now indicated by the online encyclopedia Wikipedia (https://fr.wikipedia.org/wiki/Camélologie)! And that's how I became a bit like the father of world camelology!

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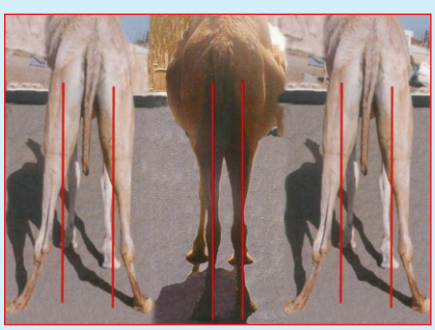

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MY JOURNEY TO CAMEL SCIENCE AS A SCIENTIST OF INFECTIOUS DISEASES OF CAMELIDS

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Central Veterinary Research Laboratory, Dubai, UAE

My Interest in camels was born

It was in the year 1975 when I was hit by the camel bug. To that time, I was working with the German Development Ministry in Somalia producing Rinderpest and Contagious Bovine Pleuro Pneumonia (CBPP) vaccines in Mogadishu, in an institute at kilometer seven which is now sadly destroyed by tribal fighting (Fig 1). Both bovine diseases were endemic in Somalia and eleven well-equipped vaccination teams, one in each district, went out every day vaccinating cattle. With a small device a piece of skin was cut out of the ear of each vaccinated cow and over the years, when travelling through the countryside, one saw more and more cattle with ear holes. Soon I realised, that dromedary camels which often accompanied cattle herds to new grazing grounds were unaffected by these two diseases. During these days, one morning two Somali pastoralists, who travelled the whole night to see me in Mogadishu, told me that one of their dromedary camel had contracted Foot-and-Mouth Disease with severe salivation. FMD was also endemic in Somalia. It was still dark when we arrived at the camel borma having passed a terrible truck accident in which two young Somalis had hit a parked unlighted truck from behind being killed, sitting dead in their truck cabin.

The adult sick female dromedary salivated profusely. We restrained it and while opening its mouth, I saw an acia twig entangled in its throat. These two incidents made me alert and I started to contemplate, to admire and to learn about the ship of the desert, as I did not know a lot about camelids and nothing we had learned about camels during our study of Veterinary Science at the Free University in Berlin. They did not exist. My interest in learning more about this animal slowly spread among the Somali pastoralists and I was asked more often to help, when camels were diseased, but these were often minor injuries, tick infestation, some wounds, nothing really serious except for some cases of jidri (camelpox). During these early days, I learned a lot and the camel owners showered me with gifts which often consisted of beautifully carved-out hair combs or head rests (Fig 2).

The contact to Somalia is still alive even after 50 years and sometimes I give zoom lectures on camel diseases to the Somali students in Mogadishu.

Collecting camelid literature

During this 2-year tenure in Somalia with 6 million head of dromedary camels, I never came across a camel with FMD, PPR, Rinderpest, CBPP or African Horse Sickness and I wondered why? Here I made a decision for the rest of my professional life: I must work with camels; the camel bug had hit me. And the chance came in 1987, eleven years later. Serious camel research began in that year at the Central Veterinary Research Laboratory, in Dubai. His Highness Sheikh Mohammed Bin Rashed Al Maktoum who established CVRL two years earlier deserves the gratitude of camelid owners and veterinarians all over the world for having the foresight to establish a camel research institute. The beginning was bumpy as scientists knew nothing about the *Camelidae* family and my first step was to establish a camel library. There was very little camelid literature available and publications were in different languages, which I did not know. However, many people helped me retrieving the available literature. Prof Rolf K. Schuster, who had studied veterinary science in Moscow, translated many camel scientific papers of Bactrian and dromedary camels from Russian into English, originating from the former Russian states which had a serious interest in their indigenous camel population. This source has now completely dried up. Only Kazakhstan had recently started some research in camel diseases and milk. Today, nearly 40 years later, CVRL has collected several thousands scientific camel papers. Through my study of the camelid literature, I soon realised a gap in camel science, giving me and my colleagues at CVRL a huge chance of camelid research, which

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finds expression in more than 600 published scientific research papers and 4 books by CVRL, another one appearing this year 2025 dealing with the anatomy of the dromedary camel.

The Real Camelid Research Started

Hundred thousand of blood samples mainly from racing camels were tested in the first decade of my tenure at CVRL and haematological and biochemical reference values statistically established, which are now commonly used. Additionally, vitamin and mineral reference values were also established.

Early research concentrated on camel milk, which I named the "white gold of the desert" and in 2000 "Camelicious", a camel dairy was established after I had explained H.H. the medicinal properties and the benefits of camel milk and its products when we travelled together to New market in his private jet. An enzyme was found, Gammaglutamyl transferase (GGT), a potential marker for the evaluation of heat treatment of camel milk opening the way for export of camel milk to the US and the European market. Even more important for the export of camel milk were our experimental infections of Old World Camels with FMDV with the support of Pirbright, UK, the world FMD centre. These experiments confirmed that the two closely related camel species, the Bactrian and the dromedary camel, possess notably different susceptibilities to FMD. During our microbiological investigations of camel milk, we isolated a new bacterial species, which was named *Camelimonas lactis* (Fig 3).

Other CVRL investigations also showed that it had been incorrectly assumed for a very long time, that one-and two-humped camels derive from a sole wild species, the two-humped wild camel. CVRL investigations showed that this was a false statement and it is now agreed that Old World Camels (OWCs) consists of three separate species: *Camelus bactrianus, Camelus dromedarius* and *Camelus ferus*.

The camel is not only a wonder of productivity and a multipurpose animal providing us with useful

Fig 1. 1975, The Veterinary Vaccine and Research Institute in Mogadishu, Somalia, now destroyed.

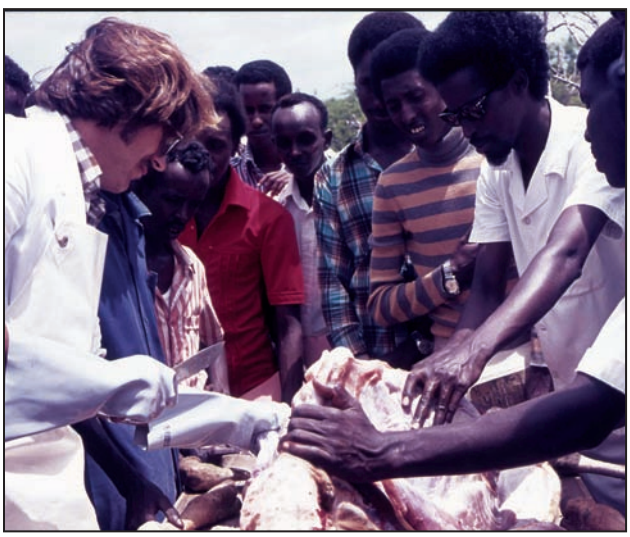

Fig 2. Teaching veterinary Somali students a necropsy with Ahmed Salad, my faithful assistant.

Fig 3. Reading culture plates in Bacteriology department of CVRL.

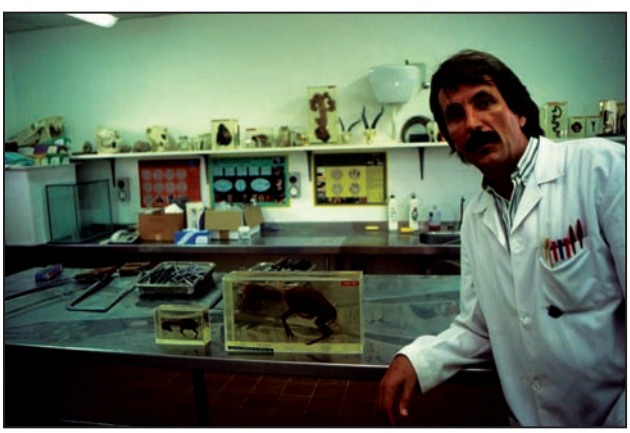

Fig 4. The dromedary camel embryo from which CVRL's Dubca permanant cell line orginates.

Fig 5. Necropsy in Dubai desert on a racing camel with H H Sh Mohammed Bin Rashid Al Maktoum.

Fig 6. Producing a dromedary camel skeleton.

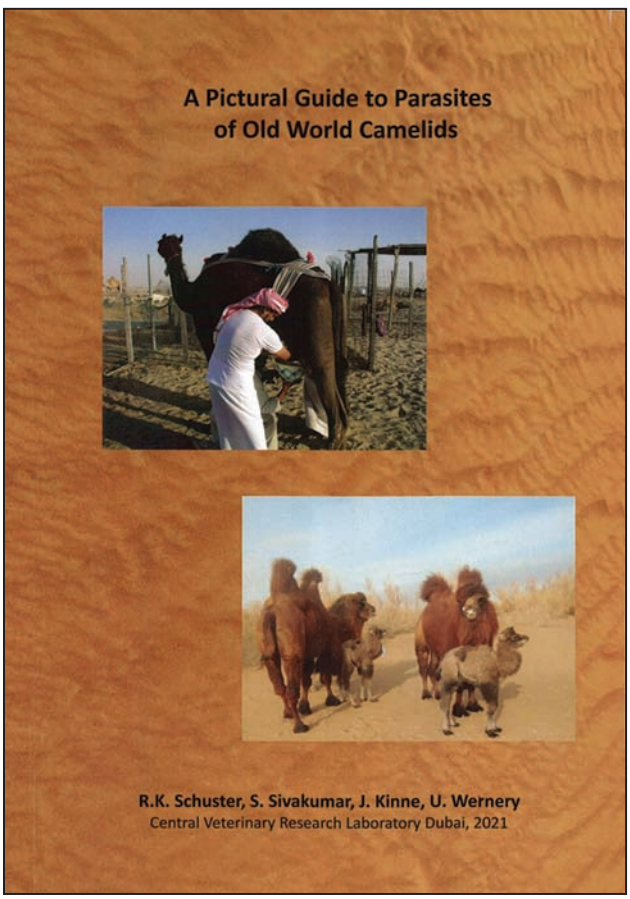

Fig 7. A Pictural Guide to Parasites of Old World Camelids.

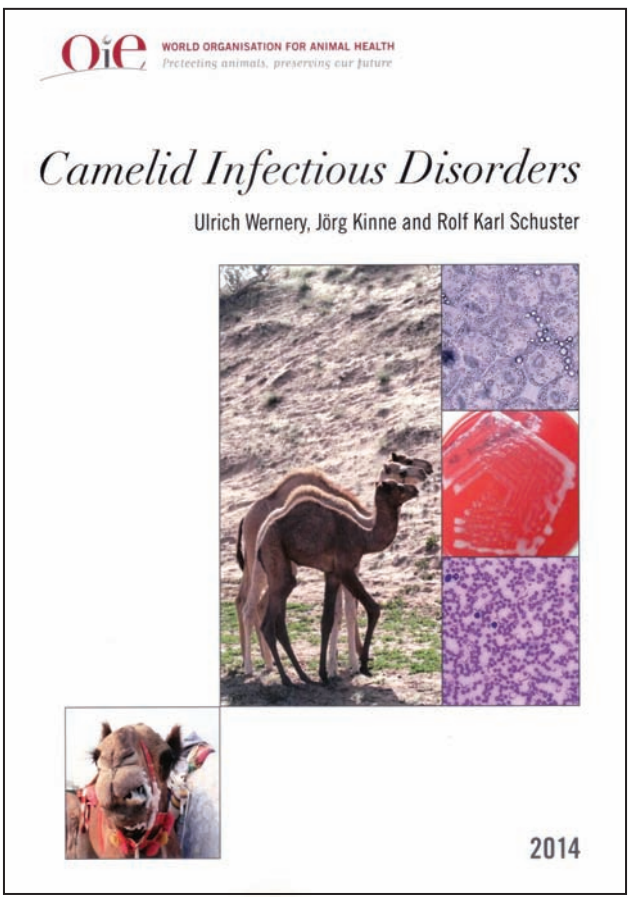

Fig 8. Camelid Infectious Disorders - OIE Replication.

products and services, it also possesses a unique humeral immune system, detected only in 1992 and had become a source of very serious and high-quality research for various medical and biotechnological applications. All *Camelidae* have, in addition to their normal antibodies, a much simpler antibody variants, novel class single-domain antigen building fragments, derived from heavy-chain camelid antibodies, known today as VHH (single variable domain heavy chain antibodies) or nanobodies. These nanobodies were produced at CVRL by immunizing CVRL dromedaries for hyperimmune serum production, anti-snake venom and against different diseases used as control sera for various serological tests. CVRL research concentrated also establishing serological tests for example ELISAs for the diagnosis of antibodies against more than 15 viral, bacterial and parasite diseases including brucellosis. We followed

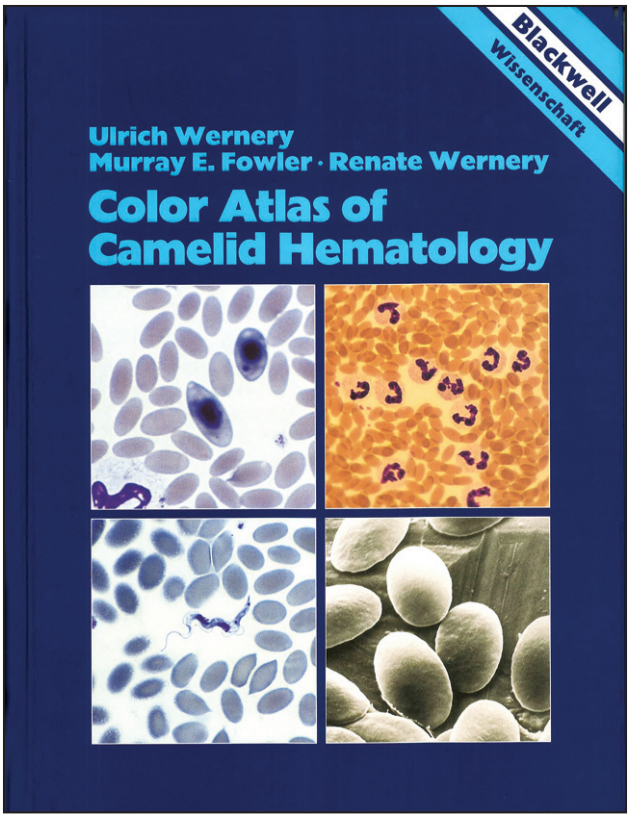

Fig 9. Color Atlas of Camelid Hematology.

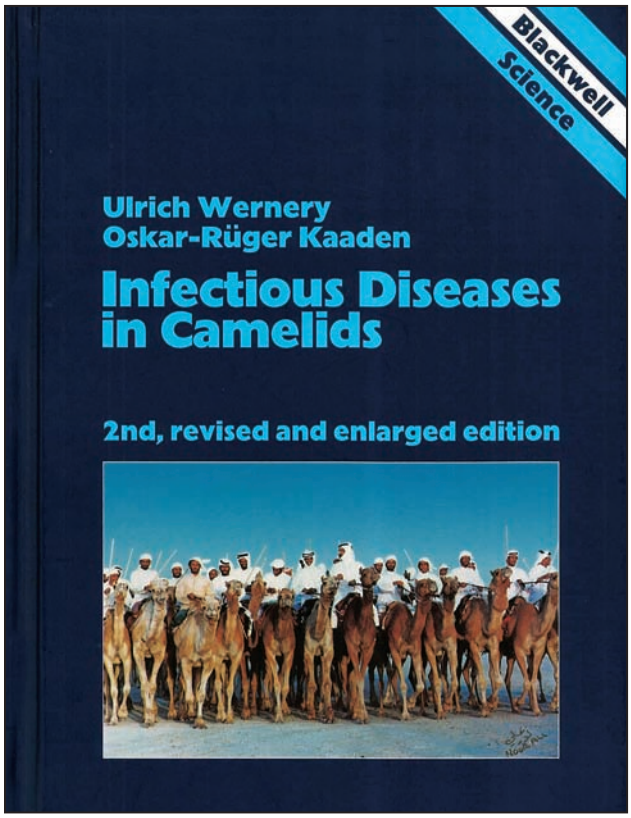

Fig 10. Infectious Diseases in Camelids.

recommendations laid down in the WOAH Manual and for camel brucellosis 15 *Brucella* serologically negative dromedaries, donated by H.H., were infected with *B. melitensis*. This investigation showed which serological test and which test kits were adequate for the diagnosis of camelid brucellosis and other diseases.

One of my very early aim was the development of a vaccine against camelpox, a viral disease endemic in all camel rearing countries except Australia. It is not really fatal but general jidri invites many bacterial species to invade the affected animals. The attenuated virus protects camel life long and was essential for racing camels. Infected racing camels would miss an entire racing year. Other vaccines produced at CVRL are against contagious lymphadenitis as well as inactivated auto vaccines against *Staphylococcus* sp. and *Salmonella* sp. All inactivated vaccines need an adjuvant and in extended experiments using many different adjuvants the optimal adjuvant was found which gives good protection with no side effects.

My camel scientific journey is far from over and the achievement we have so far made within this nearly 40 years are remarkable. The work was always supported by my family and the viral research establishing two permanent camel cell lines and isolating many different camel viruses was achieved by my wife Renate Wernery and her viral team at CVRL (Fig 4).

During the early years of my work at CVRL, a devastating disease, resembling Rinderpest, was widespread in racing camels in the UAE and on the Arabian Peninsula. It was my task to find the cause of this disease which took a long time to resolve (Fig 5 and Fig 6). The mortality was mainly among racing camels which receiving a wrong diet producing compartment 1 acidosis associated with haemorrhagic diathesis causing multiorgan dysfunction and coagulopathy and disseminated haemorrhages. I named the disease Haemorrhagic Diathesis (HD). It is now common practice in the UAE to treat acidotic dromedary camels orally through stomach tube or bottle with three to five litres of sieved C1 or rumen fluid brought from abattoirs.

Future Projects

Camel science can only be successful through cooperation and therefore CVRL has built friendship with many world class institutions all over the world in US, Taiwan, Hong Kong, UK, Germany, France and India.

New projects are in the pipeline and hopefully during my professional career they become a reality:

a camel vaccine unit, a camel milk laboratory and my very ambitious wish the establishment of a Nanobody Research Institute for the treatment of human cancer.

Scientists have already produced CAR-T cells with a CAR receptor comprising a camel VHH binder for binding to the BCMA tumour antigen on multiple myolema cells, killing them. This is the future of cancer treatment.

Acknowledgement

I am really grateful to Dr. T.K. Gahlot, who brought out this series of journeys of camel scientists to camel science in the Journal of Camel Practice and Research (JCPR). I am proud to be a member of the editorial board of this journal which provided biggest platform to publish scientific papers related to the camels and camelids. I was a co-author along with Dr. T.K. Gahlot, of a book "Selected Research on Camelid Immunology" which was published by the Camel Publishing House, India. I wish that Dr. Gahlot would continue the endeavours to strengthen the publication of camelid literature through JCPR.

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MY JOURNEY TO CAMEL SCIENCE FROM MESHGINSHAHR TO DUBAI

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ABSTRACT

Over the decades, my journey has been marked by equal parts of challenge and triumph. From grappling with the complexities of semen collection, processing and artificial insemination in camels to the development of innovative semen extenders, and from conducting pioneering interspecies embryo transfers to tackling public health concerns through camel milk research, each step has been a testament to the resilience and adaptability required in this field. It has been a journey woven with collaboration, working alongside brilliant scientists, inspiring students, and visionary leaders from around the globe. As I transitioned from Meshginshahr's Bactrian camel research station to leading high-tech facilities in Dubai, the scope of my work expanded, but the heart of it remained the same: a deep respect for camels and a desire to preserve and understand their unique biology. With every challenge faced, whether it was semen viscosity or the threat of species extinction, there was the thrill of discovery and the satisfaction of overcoming obstacles once thought insurmountable. It is my hope that the work we have done, and continue to do, will inspire others to take up the mantle of camel research, ensuring that these incredible creatures remain a vital part of our world for generations to come.

Key words: Camel, embryo, reproductive technologies, semen

My first exposure to camel science went back to early 1980s, when I was undergraduate student at the Faculty of Veterinary Medicine, University of Tehran, Tehran, Iran. At that time, I had a part- time job at the Iranian Ministry of Agriculture, when Late Prof Andrew Higgins, who was a FAO consultant, was invited to visit Iran to run a one-week workshop on camel health and disease. It was a magnificent opportunity for young student in veterinary medicine to expose to camel science. About 30 veterinarians from all over our country attended that workshop. I was part of our group at the Ministry of Agriculture to arrange the facilities for the workshop. At the same time, I enjoyed the topics presented by Prof. Higgins which I have never been exposed previously. I returned to my country in 1997, after accomplishing my postgraduate studies and post-doc in cattle and pig reproductive technologies at the University of Queensland and Common Wealth Scientific and Industrial Research Organisation (CSIRO) in Australia. Initially, after my return to Iran in 1997, I was appointed as senior researcher responsible for reproductive laboratories at Animal Science Research Institute, Ministry of Agriculture. In 1998, the director of our research group mentioned that, he is keen to explore the difference in fattening performance between the purebred dromedary and the cross breed between dromedary and Bactrian camel. My mission was to inseminate the dromedary camel with Bactrian camel semen. Initially, the topic seemed to be simple, but the reality quickly proved far more complex. Simply I did not have enough practical knowledge to accomplish the task. Moreover, artificial insemination in camel from that time till now has encountered several obstacles that I enumerated them in my recent review article (Niasari-Naslaji, 2023b). Therefore, I started my real journey to camel science since 1998 by starting this project. I settled in our Bactrian camel research station in Meshginshahr, Ardabil province, Iran, during breeding season of 1998 to collect and process the semen and to make it ready for insemination. But all attempts to collect good quality semen were nearly unsuccessful and the processing of camel semen was another dilemma due to high viscosity of semen. I have tried several times all materials and methods presented by Chinese scientists working on semen collection, processing and AI in Bactrian camel. Unfortunately, I did not achieve any promising results. In 1999, a workshop on Camel Reproduction brought to my attention. It was organised by Dr Lulu Skidmore (Fig 1) in Camel Reproduction Centre, Dubai, UAE. It was an excellent workshop held at the right time for me. I learnt a lot from Dr Skidmore and scientific collaboration is

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continuing till now. Following my return, I collected good quality Bactrian camel semen and inseminated some dromedary camels but, the problem of semen processing became a big challenge. Every year, I attended Bactrian camel research station during the breeding season and worked on semen to find out the solution to overcome the problem of semen viscosity and processing. Luckily, I had a postgraduate student, Dr Samad Mosaferi (Fig 2), who was doing his thesis with me on "Biophysical and biochemical characteristics and preservation of Bactrian camel semen". We were able to characterise Bactrian camel semen (Mosaferi *et al,* 2005). Accordingly, we found the osmolality of 316.1 ± 1.48 mOsm/kg H_2O and the pH of 7.4±0.03 for Bactrian camel semen. We also suggested the method for partial removal of semen viscosity using magnetic stirrer, set at very low speed in association with deformed paper clip. The method was very simple and effective. Semen loses its viscosity and became ready for sampling and processing. Another problem in camel semen processing was the lack of defined extender. We tested lactose and sucrose extenders suggested in the literature but in vain. Even at initial extension, we observed great shock to sperm motility. Then after three years hard work on semen processing, I have innovated an extender to preserve Bactrian camel semen named "SHOTOR diluent" (SHOTOR means camel in Persian language; Niasari-Naslaji *et al,* 2006). Once we diluted Bactrian camel semen in SHOTOR diluent, it was a revolution in sperm motility. All of a sudden, the sperm that could not move properly in lactose and sucrose extenders, could move freely with high speed, similar to what we saw in bull and ram semen. We have patented SHOTOR diluent in Iran. Then we tried to cryopreserve Bactrian camel semen using SHOTOR diluent (Niasari-Naslaji *et al,* 2007). Although the post-thaw motility was not great, about 35%, it was initial step toward successful semen cryopreservation of Bactrian camel semen. SHOTOR diluent has proved to be similar or even better than commercial camel semen extenders produced by IMV company named "Green and Clear buffers".

Years 2007-2009 were great years for me to have two enthusiastic and talented post graduate students, Dr Darab Nikjou and Dr Asghar Moghiseh. They worked together on different topics in Bactrian camel reproduction. Luckily, we had Dr Skidmore as unofficial co-supervisor (Fig 3). Lulu accepted my invitation to assist us on synchronising follicular wave cycle, multiple ovulation and embryo transfer in Bactrian camel (Fig 4). She came to Iran twice and helped our research team. In the first attempt, we were able to characterise follicular dynamics in Bactrian camel (Nikjou *et al,* 2008). The problem was the fact that Bactrian camel was under the threat of extinction and just 150 of this species left in our country. My national mission, assigned by the Ministry of Agriculture and the Governor of Ardabil province, was to provide the solution to preserve Bactrian camel in Ardabil province. According to the literature, both dromedary and Bactrian camels have the same number of chromosomes (37 pairs), similar type of placenta (diffuse type) and similar gestational length (around 12.5 months). Therefore, the hypothesis was, it might be possible to perform successful interspecies embryo transfer, collecting embryos from Bactrian camel donor and transferring it to dromedary camel as recipient. In this scenario, we were able to use dromedary camels, that we have 150000 in Iran, as surrogate mother for Bactrian camels. I received several negative comments until the project was approved and funded. In 2007, we collected 14 embryos from one Bactrian camel donor (Fig 5) and following transfer, the first Bactrian camel calf (BEHNIA) was born from Dromedary mother in 2008 (Fig 6; Niasari-Naslaji *et al,* 2009). It was quite fascinating to see the Bactrian camel calf beside his dromedary mother. Behnia initiated the great news around the country and revived the hope for saving Bactrian camel from the threat of extinction. We have used that innovation to extend Bactrian camel to the hot desert environment (Niasari-Naslaji *et al,* 2014). Due to extensive research on Bactrian camel reproduction (Niasari-Naslaji, 2008), I received "Distinguished Camel Scientist Award" at International Camel Conference in 2007 (Bikaner, India) organised by T.K. Gahlot, who was famous camel surgeon and Editor of the Journal of Camel Practice and Research. In 2011, I was invited to work for Ministry of Environment, Government of Qatar (Fig 7), but unfortunately, I was unable to assist them due to my commitments at the University of Tehran.

During the years 2009-2014, due to increasing public demands to consume camel milk within the country, we started to investigate several aspects of udder health, camel milk properties and its effect on diabetes. We characterised milk sampling for bacteriogical and somatic cell count (Arabha *et al,* 2013), investigated acute phase protein as biomarker to detect subclinical mastitis (Ghaffari *et al,* 2016) and determined the cut-off point for subclinical mastitis in camel (Niasari-Naslaji *et al,* 2016). I collaborated with Prof. A. A. Moosavi-Movahedi, at the Institute

Fig 1. Iranian participants at camel reproduction workshop with Dr Lulu Skidmore (1999).

Fig 2. Semen collection in Bactrian camel by Dr Samad Mosaferi (2002).

Fig 3. Uterine flushing in Bactrain camel, from right to left, Dr Nikjou, Dr Skidmore, Dr Moghiseh, Mr Razavi (2006).

Fig 4. My collaboration with Dr Skidmore in Iran (2006).

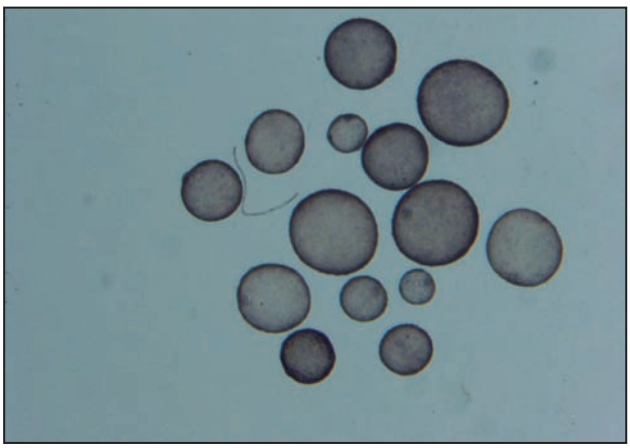
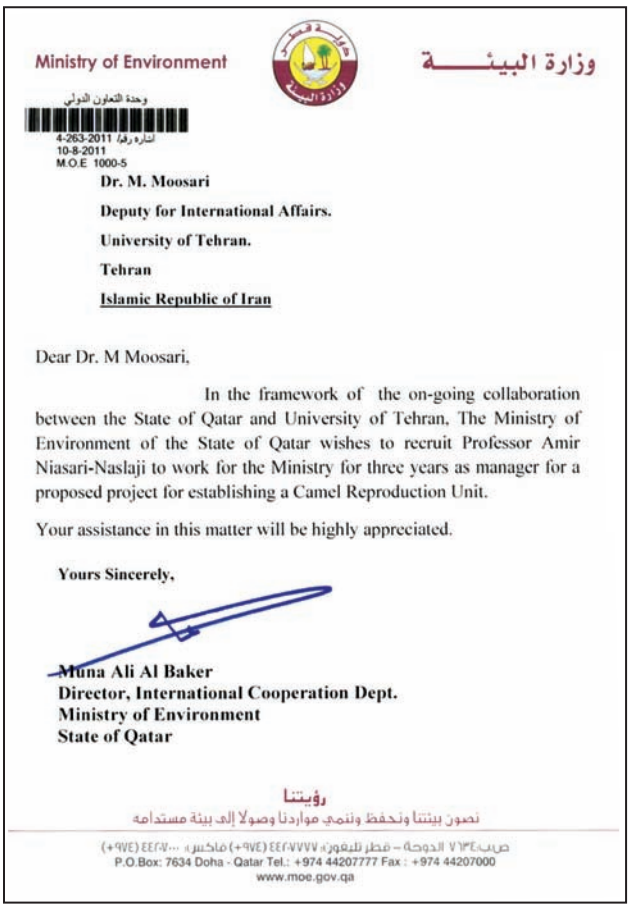


Fig 5. Fourteen hatched blastocyst embryos recovered from Bactrian camel donor (2007).

Fig 6. Bactrian camel calf, BEHNIA, was born from dromedary camel surrogate mother (2008).

of Biochemistry and Biophysics, University of Tehran, Tehran, Iran, and worked on bioactive peptides in camel milk (Salami *et al,* 2010; Moslehishad *et al,* 2013), and also with Prof. F. Azizi, at Endocrine Research Centre, Research Institute for Endocrine Sciences, Shahid Beheshti University of Medical Sciences, Tehran, Iran, to work on the effect of camel milk on diabetic patients (Ejtahed *et al,* 2015; Fallah *et al,* 2019).



Ministry of Environment

وزارة البيئـــــة

وحدة التعاون الدولي

اشارة رقم/ 4-263-2011
10-8-2011
M.O.E 1000-5

Dr. M. Moosari
Deputy for International Affairs.
University of Tehran.
Tehran
Islamic Republic of Iran

Dear Dr. M Moosari,

In the framework of the on-going collaboration between the State of Qatar and University of Tehran, The Ministry of Environment of the State of Qatar wishes to recruit Professor Amir Niasari-Naslaji to work for the Ministry for three years as manager for a proposed project for establishing a Camel Reproduction Unit.

Your assistance in this matter will be highly appreciated.

Yours Sincerely,

Muna Ali Al Baker
Director, International Cooperation Dept.
Ministry of Environment
State of Qatar

رؤيتنا
نصون بيئتنا ونحفظ وننمي مواردنا وصولا إلى بيئة مستدامه

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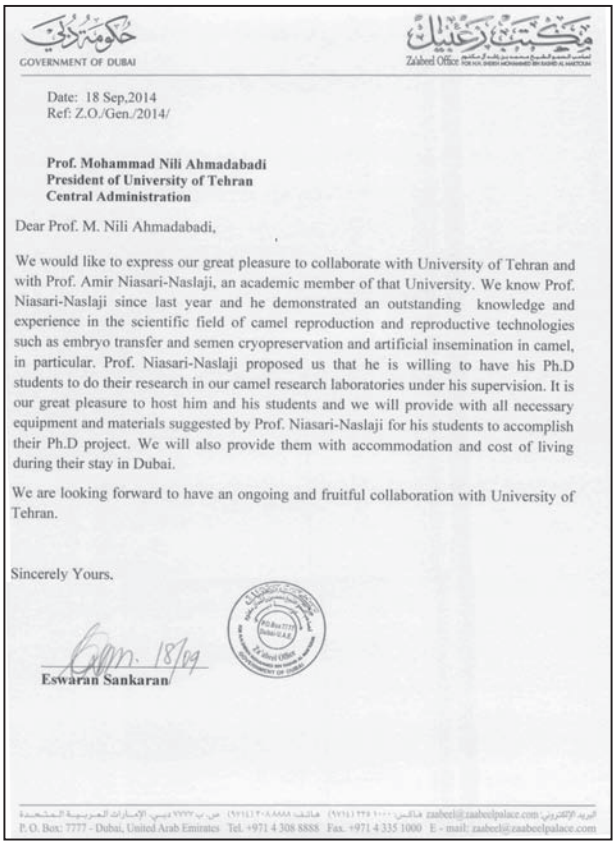
Fig 7. An Invitation letter from Ministry of Environment, Government of Qatar (2011).

Fig 8. Camel Dummy (CARTC, Margham, Dubai, UAE, 2015).

During years 2013 and 2014, at the North and North-East Camel Breeding Centre, Toroud, Shahroud, Semnan province, Iran, and with the assistance of my students, Dr Ziapour and Dr Keshavarz, we investigated semen collection and semen viscosity in dromedary camel. We innovated camel phantom for semen collection (Fig 8; Ziapour *et al*, 2014) and investigated the effect of Ficin enzyme to remove semen viscosity (Keshavarz *et al*, 2016).



حكومة دبي
GOVERNMENT OF DUBAI

مكتب زعبيل
Zaabeel Office

Date: 18 Sep,2014
Ref: Z.O./Gen./2014/

Prof. Mohammad Nili Ahmadabadi
President of University of Tehran
Central Administration

Dear Prof. M. Nili Ahmadabadi,

We would like to express our great pleasure to collaborate with University of Tehran and with Prof. Amir Niasari-Naslaji, an academic member of that University. We know Prof. Niasari-Naslaji since last year and he demonstrated an outstanding knowledge and experience in the scientific field of camel reproduction and reproductive technologies such as embryo transfer and semen cryopreservation and artificial insemination in camel, in particular. Prof. Niasari-Naslaji proposed us that he is willing to have his Ph.D students to do their research in our camel research laboratories under his supervision. It is our great pleasure to host him and his students and we will provide with all necessary equipment and materials suggested by Prof. Niasari-Naslaji for his students to accomplish their Ph.D project. We will also provide them with accommodation and cost of living during their stay in Dubai.

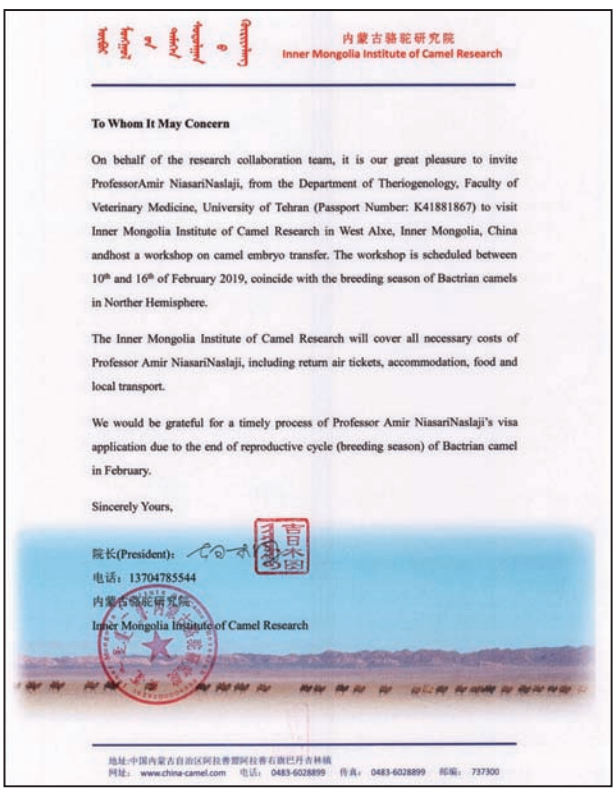
We are looking forward to have an ongoing and fruitful collaboration with University of Tehran.

Sincerely Yours,

Eswaran Sankaran

P. O. Box: 7777 - Dubai, United Arab Emirates Tel. +971 4 308 8888 Fax. +971 4 335 1000 E - mail: zaabeel@zaabeelpalace.com

Fig 9. An Invitation letter from Zaabeel office, Government of Dubai (2014).



内蒙古骆驼研究院
Inner Mongolia Institute of Camel Research

To Whom It May Concern

On behalf of the research collaboration team, it is our great pleasure to invite ProfessorAmir NiasariNaslaji, from the Department of Theriogenology, Faculty of Veterinary Medicine, University of Tehran (Passport Number: K41881867) to visit Inner Mongolia Institute of Camel Research in West Alxe, Inner Mongolia, China andhost a workshop on camel embryo transfer. The workshop is scheduled between 10th and 16th of February 2019, coincide with the breeding season of Bactrian camels in Norther Hemisphere.

The Inner Mongolia Institute of Camel Research will cover all necessary costs of Professor Amir NiasariNaslaji, including return air tickets, accommodation, food and local transport.

We would be grateful for a timely process of Professor Amir NiasariNaslaji's visa application due to the end of reproductive cycle (breeding season) of Bactrian camel in February.

Sincerely Yours,

院长(President):
电话：13704785544
内蒙古骆驼研究院
Inner Mongolia Institute of Camel Research

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网址： www.china-camel.com 电话： 0483-6028899 传真： 0483-6028899 邮编： 737300

Fig 10. An invitation letter from Inner Mongolia Institute of Camel Research, China (2019).

Fig 11. Bactrian Camel Station, Meshginshahr, Ardabil Province, Iran (2006).

Since then, semen collection became very easy job. Semen specimen had a high quality without any sand or debris (Niasari-Naslaji, 2023b). We found that proteolytic enzymes like Ficin can remove semen viscosity but had deleterious effects on sperm viability. Therefore, we decided to continue employing the mechanical approach for reducing the semen viscosity until a new, safer alternative is discovered.

In 2014, I received an invitation from Government of Dubai (Fig 9) to establish research centre in Margham, Duabi, UAE. I founded "Camel Advanced Reproductive Technology Centre (CARTC)" during years 2014 and 2015. My students were settled in the centre. We set a protocol for multiple ovulation and embryo transfer in racing camels (Ararooti *et al,* 2018) and innovated an extender named "HASHI diluent" for dromedary camel semen (Panahi *et al,* 2017). My students are still working at that centre. I have arranged several workshops on camel reproduction throughout my scientific career. One of the most important workshop was hosted in February 2019, when I was invited by the Inner Mongolia Institute of Camel Research to present 6 days' workshop on Bactrian camel reproductive technologies for Chinese veterinarians at Alten Ava, Alxa, Inner Mogolia, China (Fig 10). More recently in 2023, I was recognised among the top 20 researchers in camelid science for the last 145 years (Kandeel *et al,* 2023; Fig 11). In 2023, I wrote three review articles on camel semen (Niasari-Naslaji, 2023b), superovulation (Niasari-Naslaji and Nikjou, 2023) and cloning (2023a). Currently I am collaborating with my friend Dr. Abdelhaq Anouassi (Fig 12) at Advanced Scientific Group, Abu Dhabi, UAE, on semen collection, processing and cryopreservation and some aspect of superovulation in racing camel.

Fig 12. Advanced Scientific Group, Abu Dhabi, UAE from right to left: Dr. Abdelhaq Anouassi, Myself, Dr. Zinelabidin Arhzaf, Mr. Mustatha Adnani (2025).

Acknowledgement

I am grateful to Dr. Tarun Kumar Gahlot, Editor, Journal of Camel Practice and Research for envisioning a special column, "My Journey to Camel Science" and inviting me to write down my experiecnes in the real scientific journey to the camel science.

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MY JOURNEY TO CAMEL SCIENCE TO BECOME A CAMEL ANATOMIST

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My "Journey to Camel Science" dates back to the year 1973, the year of finishing my veterinary medicine study in Faculty of Veterinary Medicine, Assiut University, Egypt.

I loved camels and may the cause is my inspiration from a text from the Holly Quran, Surat Al-Ghāshiyah / 17 which says: "Then do they not look at the camels - how they are created?". So it must be something peculiar in these animals.. the camels!

My Master thesis in anatomy was on the "Blood vascularisation of the kidney of the dromedary. Anatomical and histological study" which I finished in Assiut in 1976.

The Ph.D. thesis in anatomy was on the "Vascularisation of the pelvic limb of the camel with special reference to the foot pad" which I finished in Assiut in 1979. The glomerulus-like structures in the camel's foot pad were described in this study for the first time.

My first visit abroad, Germany, was to the Institut für Anatomie in Justus-Liebig Universität, Giessen was in 1981. I spent there two years and returned back home with 9 publications and very good relations. The first publication was on the cartilages of the camel larynx (published in Zentralblatt Vet. Med. C, 1983, 12: 77 84). I took the samples of the work with me from Egypt, as I used after that in my yearly visits to Germany. I returned to Egypt after getting a Diploma in "High Education and International Development" from Kassel University (in 1983). I came back also with my future German wife Dr. Brigitte Schenk, who I met in the same Institut in Giessen. She came back to Egypt after finishing her Ph.D. in Histology. She is my companion in my journey to camel science including all the congresses and the visits to every place where camels exist.

Another stop in my career, while working on a research on the radiology of the camel skull (published in Vet. Radiology, 1990, 31: 161 164). I decided to broad my knowledge in Radiology,and registered for a second Master Degree in Veterinary Surgery on the teeth of the goats and got the degree in 1992 from Assiut University. Then after, I registered for the second Ph.D. in surgery and passed the first year in 1994 and completed the thesis after that.

In the year 1989 I was promoted and got the title of Professor of Veterinary Anatomy and Embryology. Then after, I moved from Assiut University in 1998, to the University of Sadat City (former a branch from Menoufiya University) and founded there the Department of Anatomy and Histology.

I was asked from my pen-friend (until this time) Prof. T.K. Gahlot to write a chapter on Camel movements in a multi-author book he intend to publish. I wrote this chapter and the book "Selected Topics on Camelids" was Published by The Camelid Publishers, Bikaner, India, 2000. Another contribution and co-operation with Prof. Gahlot resulted in a second book (Published by Camel Publishing House, Bikaner, India, 2011), under the title: "Selected Research on Gross Anatomy and Histology of Camels". Then I became a member of the scientific board of the Journal of Camel Practice and Research. (JCPR), edited with success by Prof. Gahlot until present.

In 2008, I published the first issue of my "Journal of Veterinary Anatomy" which was a biannual and camels had a fair share in the publication.

The other most important point in my career was the three years teaching anatomy and histology in James Cook University in Australia (2012-2015) and dissecting the animals found only in Australia. Moreover, I learnt more about the feral camel population in Australia. This chance encouraged me to add a chapter on the history of introducing camels into Australia for the first time by the Afghans or Ghans as they were called (the book "The camel journey from North America to Africa

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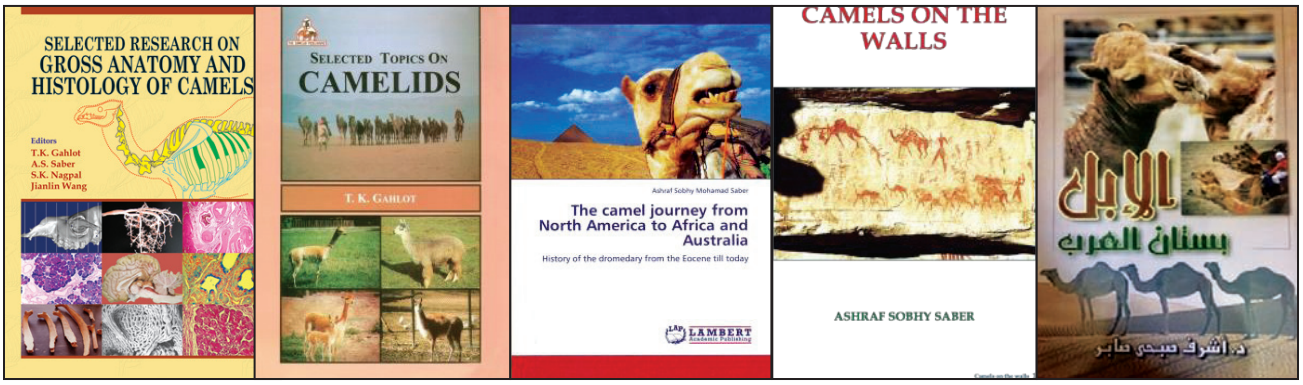

Fig 1. Camel museum, Faculty of Veterinary Medicine, University of Sadat City, Egypt. (Founded and collected by A.S. Saber, opened in 2022)

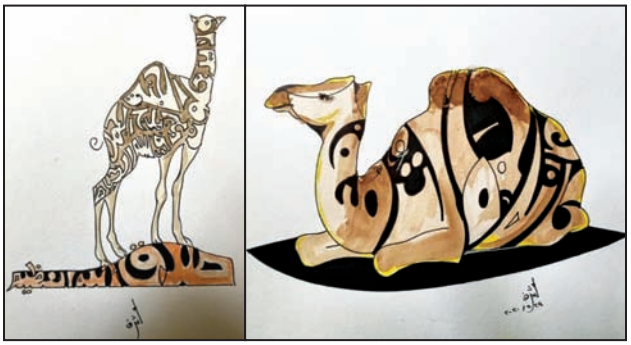

Fig 2. Arabic Calligraphy (one of my hobbies) drawing camels in a sitting and standing position. (By A.S. Saber, 2020).

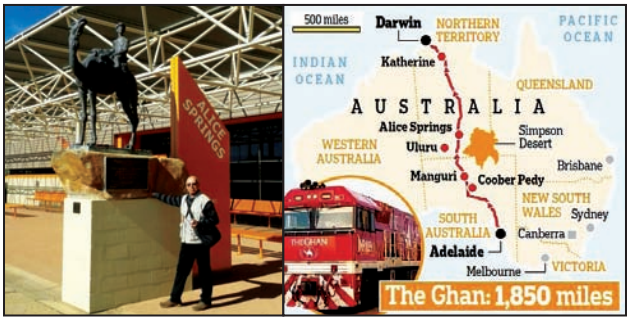

Fig 3. Alice Springs rail station in the middle of Australia where the train "the Ghan" travels southwards and northwards. The Ghan memorises the cameleers, the Afghans.

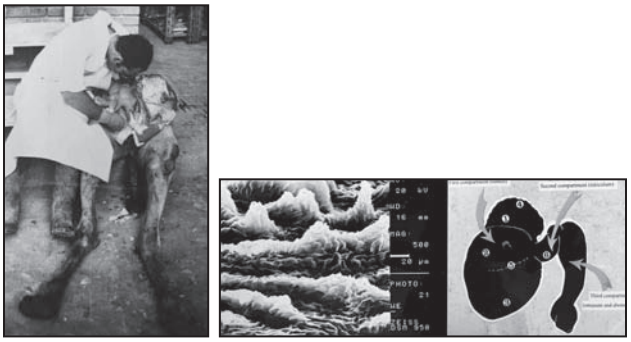

Fig 4. Dissecting the blood vessels of the hind limb of a camel (My Ph.D. thesis, 1978), left & Papillary body of the camel reticulum as seen by scanning E/M, (published in Journal of Camel Practice and Research, 1998, Vol. 5(1):51-55.), right.

Fig 5. Camel Farm in Kazaghstan (left) & Tawareq on camels, Morrocco (right).

Fig 6. Port Augusta's mayor, Mr. Noel Webb, posed on a camel with newly arrived Afghan cameleers, 1897. Photo Credit: South Australia Museum.

Fig 7. Anatomy museum, Faculty of Veterinary Medicine, University of Sadat City, Egypt. (Founded and collected by A.S. Saber, opened in 2022).

and Australia" which was published by Lambert Academic Publishing, Germany, 2013).

In Australia, also, I wrote a paper on the history of the Australian camels and the problem of its eradication and killing. I shared with it in the 4th Conference of ISOCARD, June 8-12,2015, held in Almaty, Kazakhstan and was awarded the Best Poster Award.

Another stop in my career was achieving my dream to found and finish a museum to display all the materials I collected from all over the world, for anatomy, camels, wild life, history of veterinary medicine and others (plants, fossils, stones ..etc). With the support of the President of the University, Prof. Ahmed Bayoumi, and the help of my wife Dr. Brigitte. The Camel Museum, the first and only one in Egypt was opened officially by the President of the University and the Minister of High Education in 2022.

I got 5 successive times a German Scholarship (DAAD) with three-years between each to carry out research with the German colleagues, mostly on camels (placenta, stomach, footpad) resulted in many publications and shared in international congresses.

I published more than 130 papers in anatomy, histology and history of veterinary medicine out of which about 50 were on the camels. I published 42 books in Arabic and in English, from them 5 on camels.

Nowadays, I am focusing on finish my book on the history of the camels depicted on the walls of the caves all over the continents. You can say another lane of interest in camels beside anatomy.

I had a chance to see camels in their normal habitat in the deserts or in the farms where milk is industrialised in many countries such as in Egypt, Ethiopia, Morrocco, Saudi Arabia, Jourdan, India, Kazakhstan and Australia.

I received Menoufyia University prize for the distinguish research (paper on the anatomy of the camel's nail), December 2000, Distinguished Camel Scientist Award, from College of Veterinary and Animal Science, Rajasthan Agriculture University, Bikaner, India, during the International Camel Conference, 16-17 Feb. 2007. I received also the Best Poster Award (Feral camels in Australia: past, present,

future) in the 4th Conference of ISOCARD. *June 8-12, 2015 Almaty, Kazakhstan,* and the Award of Appreciation of University of Sadat City for the entire scientific, social and artistic career, 2018, and the Albert Nelson Marquis Lifetime Achievement Award, USA, 2020.

Published Books on camels

- The Camel Journey from North America to Africa and Australia, Lambert Academic Publishing, Germany, 2013.
- Selected Research on Gross Anatomy and Histology of Camels (co-editor) Published by Camel Publishing House, Bikaner, India, 2011
- Selected Topics on Camelids (co-author) Published by The Camelid Publishers, Bikaner, India, 2000.
- Camels, the Paradise of Arabs (Published by Asela for design and Publishing, Egypt, 2001), In Arabic "191 pages".
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Saber AS and FM Makady. Anatomical and clinical studies on the lacrimal system in the camel (*Camelus dromedarius*). Assiut Veterinary Medical Journal. 1987; 19(37):17-22.

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Saber AS and Nafady A. Ultrastructure of the glomerulus of the camel (*Camelus dromedarius*). Journal of Camel Practice and Research. 1995; 2:105-109.

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Saber AD, Weyrauch KD, Hirschberg R and Riess M. Specialized vascular structures in the Pododerma of the camel (*Camelus dromedarius*) foot-pad (poster). XXVth Congress of the EAVA, Sundvolden, Oslo, 28-31 July 2004.

Saber AS (2018): Rock Art Proves the Presence and the Use of Camels in North Africa. The 5th International Congress of ISOCARD, Laâyoune, Morocco, 12-15 November, 2018.

Saber AS (2019): Camel Rock in North Africa. 18th Scientific Congress of Assiut University, Assiut, Egypt, 5-7 November 2019.

Saber AS (2022): Facts about camels. Scientific Meeting of the Egyptian Society of Camel Sciences, Sadat City. 13/12/2022

Saber AS (2024): Rock Art Proves the Presence and the Use of Camels in Asia. 1st International Congress of Nature-Based Ecological Restoration (Emphasising of Bactrian Camels), 27-18 August, 2024, University of Mohaghegh Ardabili, Iran.

Saber AS and Abdel-Naeem M. Osteogenesis of the dromedary skull (*Camelus dromedarius*) (poster) The WAVA / AAVA meeting, Tennessee University, USA. 29 July- 3 Aug. 2003.

Saber AS and Erasha AM. The nail of the camel (*Camelus dromedarius*), A morphological and scanning electron microscopical studies. (Poster) The 1st International Conference on Camels, 9-11 May 2006. Qassim, Kingdom of Saudi Arabia.

Saber AS and Hein WR. Australian Feral Camels (The Past, The Present and The Future). Joint Conference EAVA & WAHVM, 27-30 July 2016, University of Vet. Med. Vienna, Austria.

Saber AS and Hein WR. Australian Feral Camels (The Past, The Present and The Future). 4th Conference of ISOCARD, June 8-12, 20l5, Almaty, Kazakhstan (Best Poster Award).

Saber AS and Schenk Saber B. Radiographical determination of age in camel fetus. (Poster) 17th Congress of EAVA, Regensburg (FRG), 28.8 1.9.1988.

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Saber AS. Some aspects of camel history and industry. The 1st International Conference on Camels 9-11 May, 2006. Qassim, Kingdom of Saudi Arabia.

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MIDDLE EAST RESPIRATORY SYNDROME CORONAVIRUS - KINGDOM OF SAUDI ARABIA

This is the bi-annual update on the Middle East respiratory syndrome coronavirus (MERS-CoV) infections reported to the World Health Organisation (WHO) from the Kingdom of Saudi Arabia (KSA). From 6 September 2024 to 28 February 2025, four laboratory-confirmed cases of MERS-CoV infection, including two deaths, were reported to WHO by the Ministry of Health of the KSA. One of the four cases was a secondary case exposed to the virus in a healthcare facility (nosocomial transmission). Close contacts of the four cases were followed up by the Ministry of Health. No additional secondary cases have been detected. The notification of these four cases does not alter the overall risk assessment, which remains moderate at both the global and regional levels. The reporting of these cases shows that the virus continues to pose a threat in countries where it is circulating in dromedary camels, particularly those in the Middle East.

(Source: WHO website- Disease Outbreak News, 13 March 2025).

RECENT PROGRESS IN CAMEL RESEARCH

Scholars did a literature search to discover papers indexed in Scopus® using the search terms "camel", "camelids", and "Camelus dromedarius". Automatic and manual screening processes were followed.

A scanning between 1850 and 2024 revealed that a total of 15,844 camelid-related papers were published. Approximately one third of research was published within the previous 5 years (2019–2023). Camel research was included into 28 scientific topics. The top five topics were agricultural and biological sciences, medicine, veterinary science, biochemistry, genetics and molecular biology, immunology, and microbiology. The top five authors in camel research were Faye B, Wernery U, Muyldermans S, Kinne J, and Sahani MS. The top five camel research contributors among 159 academic institutions were from King Saud University, King Faisal University, ICAR-National Research Centre on Camel, Bikaner, Cairo University, and United Arab Emirates University. Out of 152 nations active in camel research, the top five were the United States, Saudi Arabia, Egypt, Undefined, and India. The top five languages were English, French, Chinese, Russian, and German. The camel research was financed by 158 sponsors, with the top five being undefined, the National Natural Science Foundation of China, the Deanship of Scientific Research, King Saud University, the National Institutes of Health, and the National Science Foundation. Camel papers have been published under 161 source titles. The top five sources were: **Journal of Camel Practice and Research**, Tropical Animal Health and Production, Indian Journal of Animal Sciences, Veterinary Parasitology, and Emirates Journal of Food and Agriculture.

(Source: Abu-seida AM, Hassan MH, Abdulkarim A, Hassan EA. Recent progress in camel research. Open Vet J. 2024; 14(11): 2877-2882. doi:10.5455/OVJ.2024.v14.i11.16)

THE CAMELID EXPERIENCE NYC 2025

The new official dates for the Camelid Experience NYC 2025 are announced. These will be June 18-23, 2025 in Chester (NY) and New York City as part of the global celebration of June 22nd- World Global Camelids Day- for sustainability and pastoralism preservation. It will highlight the vital role of camelids in ecological balance, traditional livelihoods, and climate resilience. This event will bring together science, culture, tradition, and innovation, with participants from over 30 countries. The participants will be researchers, breeders, institutions, industry leaders, and passionate enthusiasts. The programmes will include high-level conferences, hands-on workshops, a public open day, a prestigious gala dinner and an awards ceremony beside the spectacular camelid parade in the streets of New York City on June 22.

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.

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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.

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Submission of manuscript: Manuscripts should be submitted in word files to **Dr. Tarun Kumar Gahlot,** Editor, Journal of Camel Practice and Research at tkcamelvet@yahoo.com or editorjcpr@camelsandcamelids.com by online submission portals available at www.indianjournals.com or www.camelsandcamelids.com. The figures can be submitted preferably as a high pixel JPEG or other format. The manuscript should be accompanied by a covering note and author consent letter and ethical statement declaration from the author responsible for correspondence. It should also contain a statement that manuscript has been seen and approved by all co-authors. Editor and members of the editorial board are not responsible for the opinions expressed by authors and reserves the right to reject any material or introduce editorial changes. Material will be accepted for publication on the understanding that it has not been published in any other form and is not being considered elsewhere. Any material once accepted for publication may not be republished in any form without prior permission of the author. **Single blind peer review policy** is used for the manuscripts submitted and the quality standards are maintained by the JCPR editorial board and by authors who submit manuscripts for publication. A preprint PDF is provided to the author in correspondence for verification of contents and corrections, if any.

Ethical declarations in research form is an important step while submitting a manuscript to the Journal of Camel Practice and Research (JCPR). Author has to look into several questions and statements before submission. These are listed below:

Pre-submission considerations for authors

- Manuscript should have been read and approved by all the authors. All the authors mentioned in the manuscript should have agreed for authorship and it's order. An author consent letter, duly signed should accompany the manuscript as per the given format (Author in correspondence can do it). (The authorship criteria should be based on the ICMJE guidelines.)
- Full names, institutional affiliations, highest degree obtained by the authors, e-mail address (in some cases, ORCiD ID and social media handles - Facebook, Twitter, or LinkedIn) need to be clearly mentioned on the title page.
- The corresponding author, who takes full ownership for all the communication related to the manuscript, should be designated and his/her detailed institutional affiliation (including the postal address, telephone number, fax number, and e-mail address) should be provided.
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All the authors need to agree on the name(s) included in the Acknowledgement section.

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If your study involves animals, and also if your manuscript includes case reports/case series, you need to provide the following:

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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).
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Other important declarations related to funding, conflicts of interest, and more

Apart from the declarations we have discussed, there are others that authors need to consider. Let us take a look at them:

1. **Describing new taxa:** Authors must provide relevant documents and unique digital identifier for manuscripts that describe new taxa or species. They should also declare that the relevant guidelines have been followed for algae, fungi and plants, zoological taxa, bacteria, and viruses. Registration numbers for the new species (for e.g. from **MycoBank** for fungi or **ZooBank** for zoological species) should be stated in the manuscript. New virus names should be sent to the relevant study groups for consideration before publication in a journal.
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- Compliance with editorial policies and ethical standards
- Financial disclosures
- Data availability

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Following is the example:

Example:

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Le Hai[1], Rendalai Si[2], Fu-Cheng Guo[1], Jing HeI, Li Yi[1], Liang Ming[1], Jun-Wen Zhou[3], La Ba[3], Rigetu Zhao[3] and Rimutu Ji[1,2]

[1]Key Laboratory of Dairy Biotechnology and Bioengineering, Ministry of Education, Inner Mongolia Agricultural University, Hohhot, Inner Mongolia, China

[2]Inner Mongolia Institute of Camel Research, Badanjiran, Inner Mongolia, China

[3]Alxa League Institute of Animal Husbandry, Alxa, Inner Mongolia, China

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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.

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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.

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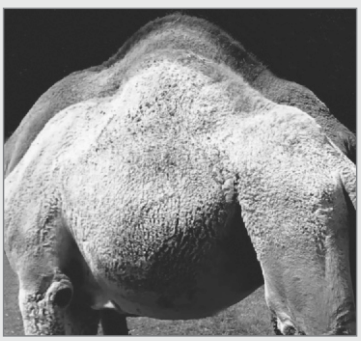

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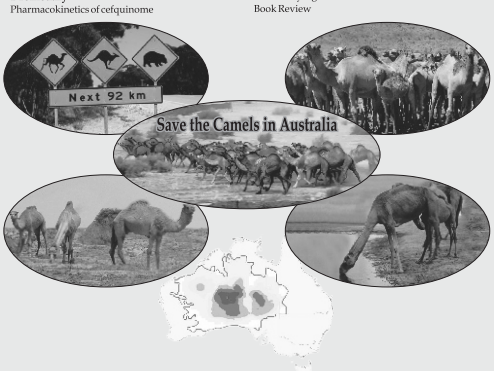

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