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Infertility in the Female dromedaries: A Review on Pathological Ovarian Structure and Uterine Pathology

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Abstract

The dromedary camel (*camelus dromedaries*) has a natural ability to produce quality meat, milk and fibre under very hot and most hostile climatic condition; however it is reproductively weak and has received the least attention among livestock animal species. Camel is a seasonal breeder, induced ovulatory and the gestation period is about 13 months. In this concise review, we shed the light on some ovarian and uterine pathological conditions that dramatically affect female camel reproductive efficiency including ovarian follicular cysts, corpus luteal cysts, persistent corpus luteum, early embryonic loss and uterine infections. These pathological conditions cause major economic losses for the camel breeders and owners and require early and careful interference to improve the camel reproduction.

Keywords: camel, corpus luteum, female, ovarian cysts

المستخلص:

يمتلك الجمل العربي (ذو السنام الواحد) قدرة طبيعية علي إنتاج لحوم وحليب وألياف عالية الجودة في ظل الظروف المناخية شديدة الحرارة والاكثر عدائية، ومع ذلك فهو ضعيف التكاثر وحظي بأقل قدر من الاهتمام بين انواع حيوانات الماشية. الجمل موسمي التناسل، محدث للإباضة وتبلغ فترة الحمل لديه حوالي 13 شهراً. في هذه المراجعة الموجزة، ألقينا الضوء علي بعض الحالات المرضية للمبيض والرحم التي تؤثر بشكل كبير علي الكفاءة التناسلية للإناث وتشمل الأكياس الجريبية المبيضية، أكياس الجسم الاصفر، الجسم الاصفر المستمر، فقدان الجنين المبكر والتهابات الرحم. تتسبب هذه الحالات المرضية في خسائر إقتصادية كبيرة لمربي الإبل ومالكيها وتتطلب تدخلاً مبكراً ودقيقاً لتحسين التناسل في الابل.

Introduction

The camel is an important animal in many areas of the world, especially in Arab countries. The low fertility rates in camels constitute an obstacle in camel reproduction

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and hence in camel production. In order to increase offtake rate in any population of camels, one has to improve the fertility rate in that population. Such an improvement may be necessary to convince camel owners to trade young camels which might then be conditioned for better meat quality (Musa *et al.*, 2006).

The total population of dromedaries consists of approximately 1.6 million animals within the Arabian Peninsula, 53% of which are found in Saudi Arabia (FAO, 2011). Bedouins prefer camel meat and milk to other types of meats and milks. Camel meat is considered to be superior to and healthier than other types of meat because of its higher protein and lower fat content; it is recommended for the prevention of cardiovascular disease and atherosclerosis because it lowers cholesterol levels in the blood. Camel meat may protect against tumours because it contains unsaturated fatty acids such as linoleic acid. Camel meat can also be used to cure exhaustion and fatigue because it contains more glycogen than other types of meat

(Kadim *et al.*, 2008). Camel milk is considered to be a complete food source that can sustain a person through a typical day. It maintains its quality and texture for 12 days and is a rich source of proteins with potential antimicrobial activities that are not found, or only found in small amounts, in other types of milk. Camel milk is lower in lactose, short-chain fatty acids and cholesterol but higher in water (89.6%), prolactin, vitamins (especially C and B1), volatile acids (especially linoleic and polyunsaturated), minerals (potassium, magnesium, iron, copper, manganese, sodium and zinc) and immunoglobulins than other types of milk (Morton, 1984; Wernery, 2007).

Despite the above-mentioned benefits of camel meat and milk, camel production is still not undertaken on a commercial scale. The reproductive efficiency of dromedary camels is generally considered to be low. Birthing rates rarely exceed 40% in nomadic herds or 70% in more intensive herds (Tibary and Anouassi, 1997a; Kaufmann, 2005; Tibary *et al.*, 2005). The persistent corpus luteum in female camels causes reproductive disturbances and infertility, in addition of causing the female camels to show false signs of pregnancy (Tibary and Anouassi, 1997b). The presence of active luteal tissue on the ovary leads to the anovulatory state where growing follicles of consecutive waves proceed to dominance but fail to ovulate. This is due to the negative feedback of progesterone on LH release. Persistent corpus luteum is mostly associated with pathological conditions of uterus such as pyometra, mummification and maceration. If these previous pathological conditions exist for months or even longer, the corpus luteum becomes centrally located in the ovary and difficult to be palpated and treated (Noakes *et al.*, 1991). In camel, the corpus luteum is usually palpated at pregnancy; however, some camels show corpora lutea in a non-pregnancy state following embryonic death and pyometra (Waheed *et al.*, 2009). Persistent corpora lutea can be treated by injection luteolytic dose of $PGF_{2\alpha}$ (Tibary and Anouassi, 1997a).

Uterine inflammation results in diminished fertility and is a considerable barrier to camel production, often resulting in significant economic loss. Uterine inflammation has been described as the most commonly encountered form of infertility in dromedary camels (Tibary and Anouassi, 2000). Inadequate clinical trials comparing the

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efficacy of different treatments for endometritis have been performed in the camel. Additionally, the efficacy of antibiotics should be evaluated periodically because resistant strains of bacteria can arise owing to the indiscriminate use of antibiotics (Vekateswaran and Rajeswar, 1991). Most veterinarians treat camels with treatments that are traditionally used for the treatment of bovine or equine endometritis, including uterine flushing, intrauterine antibiotic infusion, systemic antibiotic or a combination of the above methods. For antibiotic to be successful, it should 1) be effective against the pathogens present, 2) not inhibit the uterine defence mechanisms, 3) be effective in a pyogenic environment, 4) leave no residues in milk or meat, 5) be administered at an adequate concentration and with an adequate number of treatments and 6) be cost-effective.

Camel population:

It is difficult to exactly determine the number of camels in the world, firstly, because it is mainly an animal of nomadic people and pastoralists who are moving frequently, and secondly, because camels are not usually subjected to obligatory vaccination. So, an exhaustive census for the camels is quite difficult. Morton (1984) reported that approximately 94% of the estimated world's camel population was thought to be one-humped or dromedary camels. The two-humped Bactrian camel comprises 6% and is primarily in Asia. Seventy percent of the world's camels are located in the tropics, a majority of them in Sub-Sahara Africa. Five adjoining countries, Somalia, Ethiopia, Kenya, Sudan, and Djibouti have about 84% of African camels and 60% of the world's camels. Sudan is an agricultural country with the largest population of livestock in the Arab world and is the second in Africa after Ethiopia. In 2000, there about 37.1 million heads of cattle, 46.1 million heads of sheep, 83.5 million heads of goats and 3.1 million heads of camels.

In 2008, Arab Organization for Agricultural Development reported that Arab countries had more than 15 million camels at the end of 2008 and more than 70% of them are concentrated in Sudan and Somalia. Number was estimated to be around 7.13 million in Somalia and about 4.4 million in Sudan. Saudi Arabia had the fourth largest camel wealth with around 869,000. It was followed by the UAE which had nearly 378,000 camels (FAO, 2011). During the last decade, camel's population in Saudi Arabia decreased from 426,015 in 1997 to 260,000 camels in 2007 (FAO, 2011). Investigation of causes of this drop is important. Disturbances in reproductive efficiency might be a factor in the progressive decline in the number of camel populations in this country (Ali *et al*., 2010).

Economic importance of the camel:

The camel, known as "ship of the desert" is an old habitant to the desert where water and food are scarce and ambient temperature is high. The camel has great tolerance to high temperatures, high solar radiation and water scarcity. It can survive well on sandy terrain with poor vegetation and may chiefly consume feeds unutilized by other domestic species. The camelids inhabit the most extreme climates on the globe and their process of multiplication is determined by the availability of food and protection for the newborn (Saadeldin *et al*., 2020).

The cow milk represents 85% of the milk produced and marketed throughout the

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world. While, the camel milk production occupies a tiny place (< 1%), but finally, the dairy potential of camel appeared higher than that of the cow reared under the same climatic and feeding conditions. Moreover, the camel can be used also for packsaddle, draught and race. As a pack animal, camel is able to walk at 4-5 km/h for 10 hours with 150 to 300 kg on the back. Extreme values with 400-500 kg are reported in Pakistan. In Niger, the weight of the packsaddle is between 200 and 250 kg. The pack camel could transport this charge for 30 to 35 days, walking 60 km each day.

Camel represents a great legacy for their owners and plays a very important role in the economy and social life of Bedouins and pastoralists in different localities in the world. Historically, camels were a dependable source of not only transport but also food and milk. Arabs were proud of the number of camels they possessed; the camels were given as a bride's dowry among the Bedouin tribes. The scientific community plays an essential role for considering camel under three aspects underlying the importance of camelids, (milk, meat, power). The rapid increase in human population in the developing countries has led to a high demand for milk and meat production. The one-humped camel most probably, is a better provider of food in desert and semi-desert areas compared to cattle's which are severely affected by heat and scarcity of water and feed (Burger *et al*., 2019).

Camel reproductive physiology:

The breeding capacity is of major importance to camel owners, the decrease in reproductive performance affects negatively on camel industry. Regular monitoring of camel herd for breeding problems and/or infertility is considered a major part of herd health management (Kaufmann, 2005). In general, the reproductive efficiency of camels under their natural pastoral conditions is low. The reasons for this low reproductive efficiency compared to the other domesticated species include the short breeding season, the late age of reaching puberty, the long gestation period of 13 months and long interval between birth (Tibary and Anouassi, 1997b; Swelum *et al.*, 2018a; Swelum *et al.*, 2018b; Swelum *et al.*, 2019). Additionally, oestrous behaviour is very vague and difficult to interpret, as it does not often relate to follicular development in the ovaries.

Camels are seasonal polyoestrous. They are generally do not come in heat in the summer season. The breeding activity starts in the cold months with short days which extended from November to April in UAE (Tibary and Anouassi, 1997b).

The length of oestrus cycle varies from 14-22 days and the duration of heat is for 3-4 days. The follicle takes 2-3 weeks (interval between emergence up to be matured) and tend to be longer at begging of breeding season. Follicular wave recruitment is followed by a period of follicular growth of 3-6 follicles until the establishment of one or two dominant follicles (Tibary and Anouassi, 1997b).

The onset of sexual activities in the female camel marks the beginning of puberty and it has been found to start as early as 2-3 years of age (Tibary and Anouassi, 1997b). However, they are usually not bred until they reach their physical maturity at about 70% of their adult body weight at 3-4 years of age. The follicular waves vary between camel but can be divided into three phases: i) growth phase, ii) mature phase and iii) regression

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phase. Swelum and Alowaimer (2015); Swelum *et al*. (2018c) divided the follicular wave into two phases: i) non-breeding phase, ii) breeding phase. They considered the growth phase and regression phase as one phase and called it non-breeding phase because of overlapping between these two phases. Most females that have regressed follicles of last follicular wave have growing follicles of the next follicular wave (Swelum and Alowaimer, 2015; Swelum *et al*., 2018c). Regular ultrasonographic examination of the ovaries show that the follicle can ovulate when they reach minimum of 10 mm, length of phase (6 days) for follicular growth and maturation, all follicles that are larger than 25 mm in diameter not able to ovulate (Tibary and Anouassi, 1997b).

The ovulation in camel species is not spontaneous but induced. The factors those control ovulation in the camelids are not well understood. The ovulation can be induced by coitus (naturally) or by gonadotrophic or luteinizing hormones (LH) (Tibary and Anouassi, 1997b). Ovulation occurs 32 to 40 hours after copulation under the influence of LH. Chen *et al*. (1985) reported that ovulation can be induced by the seminal plasma, but not by the spermatozoa, and the incidence of ovulation after insemination was 87%. Most of the females (66%) had ovulated by 36 hours after insemination and the rest by 48 hours, as after natural service.

In Bactrian camels, ovulation can be induced by deep intravaginal deposition of whole semen or sperm-free seminal plasma as well as by i.m. injection of semen or seminal fluid (Zhao *et al*., 1990). In dromedaries, ovulation is induced by mating with an intact or vasectomized male, but manual stimulation of the cervix or intrauterine injection of whole semen, seminal plasma, water or the prostaglandin F analogue, cloprostenol, does not stimulate the release of sufficient LH from the pituitary to cause ovulation (Sheldrick *et al*., 1992).

The corpus luteum (CL) starts developing 2-4 days after the ovulating stimulus as a spherical, echogenic mass that grew from a diameter of 0.7 ± 0.2 cm on day 3 to 2.2 ± 0.1 cm by day 9. The CL can be palpated per rectum easy between day 8 and 10 after mating (Elias *et al*., 1984). If conception has taken place then after 15 to 25 days the she camel, especially when approached by a male or handled by an attendant, shows cocking of the tail but if she has not conceived then cocking of tail is not seen (Rathore, 1986). Pregnancy could be diagnosed at 18 days, by ultrasonography, or later if diagnosed by rectal palpation of the uterus. If the maternal recognition of the pregnancy does not occur, CL is completely regressed after 13 days (Arthur, 1985). It exhibited a secretory lifespan of 8.5 ± 0.5 days, as reflected by the serum progesterone profile. Progesterone concentrations remain low (< 1 ng/mL) then start to rise and reach 2 ng/mL by day 6 post-mating then decline to basal level (1 ng/mL) by day 15-17 in absent of conception (Skidmore *et al*., 1992). Progesterone concentrations remain low (< 0.5 ng/mL) for the first 3-4 days after ovulation and then rise to reach a mean peak of 2.6 ng/mL on day 8 (Skidmore *et al*., 1996).

If ovulation does not occur, the dominant follicle continues to grow then starts to regress; some non-mated camels develop follicles > 25 mm in diameter (cyst-like follicles). These non-ovulatory cyst-like follicles do not appear to affect fertility and other smaller follicles may continue to grow

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normally (Tinson *et al*., 1992). Thus, presence of a corpus luteum cannot be used to confirm cyclicity in camels. She-camel with ovaries presenting follicles more than 5 mm in diameter were considered as having active ovaries (Sghiri and Draincourt, 1999).

During pregnancy, progesterone level in the camelidae confirm that these species depend on ovarian progesterone throughout their pregnancy, level of progesterone remain above 2 ng/mL from the initial dictation with CL until shortly before parturition (Tibary and Anouassi, 1997a). All pregnancies are carried on the left horn whether the ovulation occurred on the left or the right ovary (Tibary and Anouassi, 2000). The placenta of camelids is epitheliochorial, and the pregnancy is located in the left uterine horn in 98% of the cases (Arthur,1985). The length of gestation is 398 ± 13 and 372 ± 11 days in camels carrying male and female fetus, respectively. The level of progesterone hormone throughout pregnancy was fluctuated between 4 and 5 ng/mL except for a slightly lower value (2.5 ± 0.27) at 9 to 10 months of gestation. On an average, the camels carrying a male fetus had higher progesterone levels (5.13 ± 0.69 ng/mL) than those carrying female fetus (3.45 ± 0.20 ng/mL) (Agarwal *et al*., 1987). The pregnancy lasts about 13 months and the uterine involution is completed within 40 days after parturition and the period of resumption of the ovarian activity after parturition is variable (Monaco *et al.*, 2015). The progesterone concentration reaches its peak after ovulation and falls immediately before parturition. (Skidmore *et al*.,1996).

Infertility in the female dromedaries:

The fertility is defined as the ability of the male and female to produce viable germ cells, mate and conceive and subsequently give birth (Mukasa-Mugerwa, 1981). Reproductive diseases and infertility in the female can be placed in one of 4 categories of complaints: Failure of the female to become pregnant (Repeat Breeding Syndrome); Failure to maintain pregnancy after breeding and conception (early embryonic death, fetal loss or abortion); Failure to complete breeding because of physical or behavioural problems (intromission difficulties, refusal of the male); Observed abnormalities in the genitalia (abnormal conformation or lesions of the vulva and perineum, abnormal vaginal discharge, etc.) (Tibary and Anouassi, 2000). Tibary and Anouassi (2000) reported that reproductive failure may be due to management errors as presenting of dromedary females which had no follicular structures on the ovaries or only follicles smaller than 9 mm for breeding, breeding with a young male, overuse of males, lack of verification of intromission during copulation.

Early pregnancy loss is probably one of the most important factors resulting in the reduction of reproductive efficiency in camels. Recognizing the occurrence and incidence of embryonic loss may be instrumental in application of new reproductive technologies to increase service rate in a herd and reduce embryonic loss in camels (Manjunatha *et al*., 2012). Early embryonic death (before Day 45) percentage in the dromedary is ranged from 8 to 32% (Tibary and Anouassi, 2000). Manjunatha *et al*. (2012) recorded 6.9% early abortion including the pregnancy loss during embryonic stage and early fetal stage in multiparous, whereas no early fetal loss was recorded in primiparous camels.

Abnormal ovarian structures:

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Ovarian cysts:

In camel's various cysts may develop in and around the ovaries. While some cysts are incidental findings at post-mortem, others are associated with fertility disturbances. Intra ovarian cysts include anovulatory Graafian follicles, cystic corpora lutea and cystic rete. Para-ovarian cysts are derived from mesonephric tubules, paramesonephric ducts, uterus and the mesosalpinx (Zaher *et al*., 2021).

Ovarian cysts are described according to the structure involved and their appearance. Cysts are classified as follicular cysts, luteal cysts, cystic corpora lutea or hemorrhagic cysts according to their histological and physical characteristics. Pathologic ovarian cysts may be follicular or luteal and may be single or multiple on one or both ovaries. Follicular cysts are thin-walled, fluid-filled structures associated with low plasma progesterone levels. Luteal cysts are partially luteinized fluid-filled structures that result in higher plasma progesterone levels (Zaher *et al*., 2021). Only follicular cysts have been described in Bactrian camels and are associated with infertility (Tibary and Anouassi., 1997a).

Ovulation failure and follicular cyst:

The cystic ovary condition is not well documented as in cattle or other domestic animals. In fact, the term "cystic ovaries" does not always apply to camelidae because a large proportion (30 to 40%) of females develop some form of follicular cyst if not bred because the ovulation in these species is induced (Tibary and Anouassi, 1997a; Tibary *et al*., 2005). If ovulation does not occur, some non-mated camels develop follicles > 25 mm in diameter (cyst-like follicles). These non-ovulatory cyst-like follicles do not appear to affect fertility and other smaller follicles may continue to grow normally (Tinson *et al*., 1992). Kaufmann (2005) reported that ovulation failure might be caused by inadequate LH release in response to copulation and the camels showed the clinical symptoms of repeat breeding and refuse mating with ovarian cysts. Therefore, ovarian cysts (5.3%) and ovarian inactivity (3.6%) did not represent major infertility problems in camels (Ali *et al*., 2010).

Cystic corpus luteum and luteal cyst:

The terms for cystic corpus luteum can often be confused with those for luteal cysts, though the first is a normally functional structure and the latter a pathological condition. Because of this, the contemporary term "corpus luteum with a cavity" has been suggested to replace the classical term cystic corpus luteum (Zaher *et al*., 2021). A cystic corpus luteum in a cow is defined as "luteal tissue initiating from a corpus hemorrhagicum and containing fluid in a central cavity greater than 7 mm in diameter. Because cystic corpora lutea are found in cows those normally cycling or pregnant, they are considered to be a normal stage or variation of CL development (Zaher *et al*., 2021).

On the other hand, the luteal cysts are an extension of follicular cysts such that the non-ovulatory follicle is partially luteinized spontaneously or in response to hormonal therapy (Zaher *et al*., 2021). The Luteinized ovarian cyst and persistent corpus luteum in female camels cause reproductive disturbances and infertility, in addition of causing the female camels to show false signs of pregnancy (Tibary and Anouassi, 1997a,b). The presence of active luteal tissue on the ovary leads to the anovulatory state where growing follicles of consecutive

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waves proceed to dominance but fail to ovulate. Anovulatory follicles do not have any negative effect on newly emerging follicular wave and ovulation of a new follicle is possible even in the presence of this structure. However, some of these anovulatory follicles can become luteinized producing enough progesterone to induce decrease in uterine tone and rejection of male. Luteinized cyst can also be the result of partial luteinization of follicle following breeding (Tibary and Anouassi, 1997a,b).

A high proportion of camels (75% 6/8) with ovarian cysts evidenced cocking behaviour for prolonged periods (more than 2 months) and a high plasma progesterone (< 1.5 ng/mL). Sonographically, cysts showed hyperechogenic streaks in an anechogenic lumen in 75% (6/8) of the camels. Whereas in 25% camels (2/8), the ovarian cysts evidenced anechogenic structure with a thick echogenic wall (Zaher *et al*., 2021).

Persistent corpus luteum:

Corpus luteum that persists on the ovary beyond day 20 without pregnancy is considered pathologically persistent. The presence of active luteal tissue on the ovary leads to the anovulatory state where growing follicles of consecutive waves proceed to dominance but fail to ovulate. This is due to the negative feedback of progesterone on LH release (Borman, 2002).

Shalash (1965) reported that persistent corpora lutea are rare in the female camelidae. However, the condition has been suspected on the basis of prolonged elevated plasma progesterone levels with absence of pregnancy (Adams, 2001). Persistent corpus luteum is mostly associated with pathological conditions of uterus such as pyometra, mummification and maceration. If these previous pathological conditions exist for months or even longer, the corpus luteum becomes centrally located in the ovary and difficult to be palpated and treated (Noakes *et al*., 1991).

In camel, high progesterone concentrations is rarely due to persistent corpus luteum but rather to the luteinisation of hemorrhagic follicles (Tibary and Anouassi, 2000). The condition of persistent corpus luteum has been suspected in llamas on the basis of prolonged high plasma progesterone level. In some cases of camels, progesterone remained higher than 2 ng/mL for 15 days or more in absence of mating and corresponded to luteinized anovulatory follicles which tend to have very slow regression (Tibary and Anouassi, 1997a,b). In camel, the corpus luteum is usually palpated at pregnancy; however, some camels show corpora lutea in a non-pregnancy state following embryonic death and pyometra (Waheed *et al*., 2009). Persistent corpora lutea can be treated by injection luteolytic dose of $PGF_{2\alpha}$ (Tibary and Anouassi, 1997a,b).

Infectious causes:

Out of 447 female camels examined for reproductive disorders, the major causes of infertility were endometritis and metritis (57.1%). Vaginal adhesions were the second important infertility problem (16.1%). While, ovarian cysts (5.3%) and ovarian inactivity (3.6%) did not represent major infertility problems (Ali *et al*., 2010). On another study, the major four infertility problems were pyometra, repeat breeder, endometritis and mucometra (Waheed *et al*., 2009). The highest frequency of repeat breeders was found during winter, whereas the number of endometritis cases was significantly higher during autumn. The infectious causes are classified into bacterial, viral and parasitic infection (Waheed *et al*., 2009).

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The problems of reproduction in the camel are not extensively investigated as in other animal species specially the bovine (Musa *et al*., 2006). Endometritis and metritis were found in mild, moderate, and severe degrees in frequencies of 117/255 (45.9%), 77/255 (30.2%), and 61/255 (23.9%), respectively (Ali *et al*., 2010). Chronic metritis accompanied with adhesions of the uterus (not freely movable) to the broad ligaments. The herd fertility in the central region of Saudi Arabia lies between 71 and 85% (Ali *et al*., 2010). There are miscellaneous causes of infertility including anomalies of the genital tract (1.1%), hydrosalpinx (0.5%), and vaginal tumours (0.5%). Early embryonic mortality seems to be high in the camel although two and three corpora lutea were found; the reason for these high prenatal losses is still open for more Investigation (Merkt *et al*., 1990).

The uterus of female dromedaries could be the site of acquired pathologies which seriously affect female fertility such as endometritis, pyometra and mucometra or be the reason for repeat breeding (Tibary and Anouassi, 2000). Factors that interfere with ova transport in the bursa (i.e. bursitis) and uterine tube (i.e. salpingitis; occlusions) or impair semen viability and transport (uterine adhesion, endometritis, obstruction of the utero-tubal junction) may be the cause of repeat breeding (Tibary and Anouassi, 2000). Uterine infection should be suspected in any animal with a history of repeat breeding or early embryonic death. Diagnosis is confirmed by the results of clinical examination. Examination of the perineum and vulva may reveal muco-purulent discharge. In some cases, the base of the tail may present dried flakes of vaginal discharge. Rectal palpation and ultrasonography may in some cases reveal a thickened uterine wall and various amount of fluid (Tibary and Anouassi, 1997a,b).

Unlike cattle, there is shortage of information regarding infective pathogens colonizing the genital tracts in camels (Mshelia *et al*., 2014). Uterine culture yields a wide variety of non-specific micro-organisms including; *Corynebacterium pyogenes, Escherichia coli, β-haemolytic Streptococci, Staphylococcus spp., Klebsiella pneumonie, Aspergillus spp., Mucor sp*p. (Wernery and Wernery, 1992).

The genitalia of camels were investigated to isolate bacteria and the antibacterial susceptibilities of some of the isolates. *Streptococcus pyogenes* (31%), *Escherichia coli* (24%) and *Staphylococcus aureus* (20%) were the most common vaginal bacterial isolates in camels (Mshelia *et al*., 2014).

The animals suffered from puerperal infections of the genital tracts are subsequently characterized by low reproductive performance (Sheldon *et al*., 2004).A total of 54 female camels with a history of conception failure were examined through trans-rectal palpation, ultrasonography and vaginal explorations. Animals were categorized according to type of uterine infection (endometritis n = 26 animals) and (metritis n = 28 animals).Several types of both gram-negative and gram-positive bacteria were isolated from diseased animals. Presences of bacteria were detected in samples (87.5%) in cases of endometritis in contrast to (92.5%) from metritis cases (Nabih and Osman, 2012).

Several microorganisms were isolated from infected camels. The microorganisms associated with endometritis were identified as *Staphylococcus aureus*, 16 isolates (40%), *Corynebacterium spp*., 8 isolates (20%),

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Escherichia coli, 6 isolates (15%) and *Salmonella spp*. 5 isolates (12.5%) (Nabih and Osman, 2012). In metritis cases, the isolated bacteria were identified as *Corynebacterium spp*.12 isolates (30%), *Proteus spp*. 10 isolates (25%), *Klebseiella spp*. 8 isolates (20%) and *Salmonella spp*. 7 isolates (17.5%) (Nabih and Osman, 2012).

The bacteria colonizing the genital tract of the female camel (*Camelus dromedarius*) have been shown to be the major causes of reproductive disorders in this species. (Ali et al., 2010).

Cephapirin, a first-generation cephalosporin, and oxytetracycline satisfy most of the criteria for the treatment of endometritis (Noakes *et al*., 1991). They are both broad-spectrum antibiotics with bactericidal action against gram-positive and gram-negative bacteria. In addition, they are both resistant to the action of penicillinase and active in an anaerobic environment. Oxytetracycline is poorly absorbed in the uterus after an intrauterine infusion (Bretzlaff *et al*., 1983), though it achieves higher, more long-lasting levels in the endometrium than if it had been administered by other injection routes (Masera *et al*., 1980). Oxytetracycline can be an irritant; thus, it stimulates the inflammatory response and uterine defensive reactions and promotes polymorphonuclear leukocytes (PMN) infiltration to the uterine lumen and the regeneration of uterine tissue. Therefore, it can be a very useful antibiotic for the treatment of endometritis, especially in cases of chronic disease. Nevertheless, it is not used by certain practitioners because it leaves residues in the milk. In contrast, cephapirin leaves no residue in milk, and it achieves concentrations in the endometrial tissue above the minimal inhibitory concentration (MIC) of sensitive bacteria for at least 24 hours after a single treatment (Adams, 2001).

The negative economic impact of a persistent corpus luteum to the camel owners:

To show symptoms of pregnancy in female camels with no factual conception is a real problem which is primarily harming the owner for the following reasons:

1. Owners are always keen to deal with their pregnant female camels with excessive and intensive care and they are keen to feed them a special type of feed at a higher cost.
2. The owner must wait for 13 months to discover that the camel is not pregnant and consequently, major loss of expenses for shelter, food, medicines and care would occur.
3. Loss of one or two mating seasons as the breeding season in the Arabian camel does not exceed five months (September to May).
4. This situation also affects the clinician vet (non specialist) as when he deals with pregnant camels, and provides them necessary treatment, with taking precautions to avoid giving drugs that might cause abortion, thus feels constrained in most cases.
5. There is also a negative impact in case of sale or purchase of the camel, where there is a big difference between the price of the pregnant and non pregnant camel, but what happens is that selling a camel that was thought to be pregnant then turns to be not, would lead to serious disputes among owners and buyers.

Conclusion

Endometritis and pathological ovarian structures are the most common causes of infertility in camels. The treatment protocols used in other animal species may be

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improper for camel treatment. The camels must have its own protocol of treatment

Conflicts of interest

No potential conflict of interest relevant to this article was reported.

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