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Anatomy of the Camel Reproductive Tract (17-Jun-2000)

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Part One: Anatomy of the Male Camel

Anatomy of the External Genitalia

Scrotum and Testes - The scrotum is located in the perineal region in camels with the testicles directed caudo-dorsally. The scrotal skin tends to be smooth and fine during the height of breeding activity and then becomes thicker during the period of sexual inactivity because of decreased testicular size.

The testes of camels are ovoid in shape and are usually descended at birth but are very small. They increase in size at the onset of puberty but there has been a wide variation in the dimensions reported. This is probably due to differences in age, breed and sexual activity at the time of measuring, but in general they vary in length from 7 - 10 cm and weigh between 80 - 100 g each [1,2]. They become enlarged and protrude when the male camels are sexually active in the rutting season. Testicular size is an important parameter in the evaluation of the breeding potential of males and can be used to predict daily sperm production because of the high correlation found between scrotal measurements testicular weight and total sperm production [3].

Seminiferous tubules - In camels the outer diameter of the seminiferous tubules has been reported to vary between 113 - 250 μm in diameter and gets significantly smaller during the non-rutting season [4,5]. The season does not however have any effect on the size of the spermatozoa although it does on their number. For example, the estimated production of camel spermatozoa is 8.1×10^6 sperm cells per day at the end of Spring and drops to 4.2×10^6 sperm cells per day at the end of the Summer [6].

Epididymis - As in other species the epididymis is composed of three distinct parts: the caput (head), the corpus (body) and cauda (tail). It is located along the dorsal border of the testis with the head curving around the cranial pole of the testis. In dromedaries, the cauda epididymis is round and well-protruded about 3 - 4 cm above the respective extremity of the testis.

Ductus deferens - The ductus (or vas) deferens are very long measuring between 45 - 50 cm in length and are enclosed within the spermatic cord.

Prepuce and penis - The prepuce is flattened from side to side and triangular in shape when viewed laterally. In the absence of sexual arousal, the small preputial opening is directed caudally and because of this they urinate towards the rear, but when erection of the penis occurs, the cranial preputial muscles pull the prepuce, and also the penis, forward from their backward position. The penis is attached to the prepuce at birth and does not become free until 2 - 3 years of age (Fig. 1).

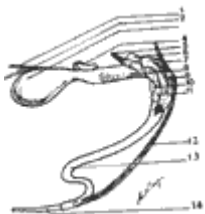


Figure 1. Anatomy of the male genitalia. 1) ureter, 2) ductus deferens, 3) urinary bladder, 4) prostate, 5) urethral muscle, 6) ischiocavernosus muscle, 7) retractor penis muscle, 9) bulbospongiosus muscle, 10) crus penis, 11) ischiocavernosus muscle, 12) retractor penis, 13) sigmoid flexure, 14) free portion of the penis. - To view this image in full size go to the IVIS website at www.ivis.org . -

The penis of the camel is of the fibroelastic type and relies primarily on its elasticity for erection and extension. In the

absence of an erection, the penis is retracted into its sheath via a prescrotal sigmoid flexure not a post scrotal sigmoid flexure, as is the case in bulls [7]. The length of the penis ranges from 59 - 68 cm and it is cylindrical in shape [7]. At its root, at the ischial arch, it has a diameter of 2.2 cm which gradually decreases to 0.4 cm at the neck of the glans penis. The glans penis is 2.6 cm long and ends in a cartilaginous process which supposedly directs the penis through the cervix of the female during copulation [2]. The glans penis is curved along its vertical plane giving it a hook-shape with a definite neck between the glans and body of the penis (Fig. 2).



Figure 2. The penis of the dromedary showing the hook-like shape of the glans penis. - To view this image in full size go to the IVIS website at www.ivis.org . -

Anatomy of the Internal Genitalia

The most important feature is the absence of seminal vesicles in the *Camelidae* family [8-10]. In dromedaries the accessory sex glands are: the ampullae, the prostate, the bulbo-urethral (Cowper's glands) and the urethral glands. The size and weight of the glands are affected significantly by the age of the animal, (tending to reach a maximum between 10.5 - 15 years [11]) and the season, with maximum gland weight being recorded during the breeding season [8,9]. This is concomitant with the increased activity and weight of the testis, that suggests that the activities of the accessory sex glands are regulated by androgen secretion from the testis [12-14].

The Ampulla - The initial part of the ductus deferens is small in diameter and very tortuous but it thickens and forms the ampulla as it approaches the pelvic urethra [9]. It averages 18 cm in length with the terminal part embedded in a deep groove located on the ventral surface of the corpus prostatae. It has been suggested that these glands may play the role of a sperm reserve before ejaculation [9].

The Prostate Gland - This is the largest and only palpable gland in the dromedary. It has two components, a compact and a diffuse part with the two forming an L shape which lies dorsal to the pelvic urethra [9].

The Bulbo-Urethral Glands - There are two bulbo-urethral glands which are almond shaped structures that are located either side of the terminal portions of the pelvic urethra [9].

The Urethral Glands - These are located just behind the body of the prostate and extend to the level of the urethral bulb before opening into the urethral lumen via numerous ducts. These glands and the pelvic urethra are richly enervated; these nerves being responsible for the contraction of the muscle and expulsion of glandular secretion [9].

Part Two: Anatomy of the Female Camel

Anatomy of Internal Genitalia

The Ovary - The ovaries are located about 36 cm from the opening of the vulva but are subject to great variations depending on the physiological stage. For example, during pregnancy they become more ventral and are pulled forward during the advancing stages thus making them very difficult to palpate. The left ovary is generally more cranio-ventral in position than the right ovary [15].

The ovary is attached to the broad ligament by a well-defined strong ligament which extends from the hilus of the ovary to the tip of the corresponding uterine horn. Both ovaries are enclosed within a fold of the mesosalpinx known as the ovarian bursa, the apex of this bursa forms a large circular orifice within which lies the fimbriae of the oviduct [15].

Their general appearance and size varies according to the age and activity of the animal. In the prepubertal animals they have a smooth and glistening surface with several raised small vesicles (2 - 5 mm in diameter) throughout the surface which correspond to the follicles. In anoestrous and nulliparous females the ovaries are oval or circular, flattened laterally and have an irregular surface due to many small follicles. During the breeding season, mature follicles and current corpora lutea (CL) project from the main contour of the ovary and give it a more lobular form (Fig. 3). This lobulation increases with increased number of previous ovulations or pregnancies and is due mainly to the presence of old corpora albicantia [15]. The free ventral border, however, does not present an ovulation fossa as has been described in equines. The measurements given for the ovary vary from 2.6 - 6 cm in length, 2 - 4 cm in width and 0.5 - 0.9 cm in thickness and each ovary weighs between 3 - 4 g in dromedaries and approximately 5 g in Bactrians [15-17]. However, they increase in weight with increasing age, ovarian

activity and during pregnancy, as during pregnancy they are bearing the CL [15,16].

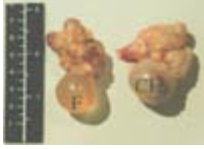


Figure 3. A pair of ovaries from a dromedary camel. There is a translucent follicle (F) on the left and an opaque corpus luteum (CL) on the right ovary. - To view this image in full size go to the IVIS website at www.ivis.org . -

Ovarian Structures - The ovary consists of two major parts (i) the cortex and (ii) the medulla and the whole organ is enclosed by a tunica albuginea except in the area of the hilus. Follicular activity takes place in the cortex and ovulation can occur anywhere on this surface. However, as camelids are induced ovulators, i.e. under natural conditions they only ovulate in response to mating, there is no cyclical appearance of a CL in non-mated females. Corpora lutea are therefore only present in the ovaries of recently bred or pregnant females [16, 18,19].

Follicles: Follicular activity is dominated by 4 types of follicles, namely: small growing follicles, mature follicles, regressing follicles or over-large, anovulatory follicles [19,20]. As the follicular waves overlap with each other, several generations of follicles may be present at the same time [20]. The small growing follicles are visible on the surface of the ovary as small slightly raised vesicles measuring between 2 - 4 mm, whereas the mature pre-ovulatory follicle measures between 13 - 20 mm [19,20] and is spherical, turgid, with a thin clear translucent wall and protrudes markedly from the ovarian surface. The appearance of regressing follicles depends on the stage of regression. At the start of regression the follicular wall becomes thick and opaque and the diameter decreases slowly until the follicle recedes into the ovary itself. Large anovulatory follicles are present in about 50% of non-mated females and their size and appearance can be highly variable [19,20]. They vary in size from 25 - 60 mm and may have a thin or thick, opaque wall and contain either serous or haemorrhagic fluid with various amounts of fibrin.

Corpus Luteum: The corpus luteum forms after ovulation, which occurs 24 - 48 hours after mating [21]. The ovulating follicle collapses at ovulation and then the follicular cavity fills with blood to form a corpus haemorrhagicum. Luteinization of the corpus haemorrhagicum occurs within 4 - 5 days and gives rise to a corpus luteum. In the non-pregnant camel the CL measures 12 - 15 mm in diameter and weighs 1.5 - 2 g [15,16], but during pregnancy the size and weight increases to an average of 22 ± 6 mm and 4.9 ± 1 g respectively. Regression of the CL occurs between 10 - 12 days after a sterile mating [22] or just before parturition in the pregnant camel. The corpus albicans, originating from the regression of the CL of pregnancy is hard, white or grey in colour and has no blood vessels on its surface. Corpora albicantia of different sizes (5 - 12 mm in diameter) can remain on the surface of the ovary of the female for a long time [16, 23].

Oviducts - As in other mammalian species the oviducts play an important role in storage of sperm, fertilization and early embryonic development. Unlike other mammals though the oviducts are enlarged at the uterine end and this unique arrangement allows prolonged storage of large numbers of spermatozoa [24]. The oviducts measure between 17 - 28 cm in length [25]. The isthmus is less coiled than the ampulla, and the fimbria lies within the bursa at a short distance from the ovary. Each oviduct opens into the uterine horn via a narrow orifice at the summit of a protuberant papilla which can be as much as 3 - 5 mm in height [25,26]. This papillae is very muscular and presents a sphincter muscle at its apex. The function of this is unknown but it is possible that it plays an important role in the selective transport of fertilized embryos.

Uterus - The uterus in all camelidae is bicornuate with the left horn being distinctly longer than the right. In nulliparous females the uterus is very small and can be found entirely within the pelvic cavity, whereas in mature non-pregnant females it is located in the abdominal cavity at the level of the 5th, 6th and 7th lumbar vertebra [27-29].

In dromedaries the non-gravid uterus has a short body of only 2 - 3.5 cm in length and the horns vary between 6 - 10 cm (right) and 8 - 15 cm (left); [30] (Fig. 4). In Bactrians the body of the uterus can be as long as 8.5 - 9.5 cm in length and the right and left horns measure between 6 - 8 cm and 8 - 12 cm respectively [17]. The endometrium of the uterine body and horns contain no caruncles [30] and the uterine glands are simple, branched and tubular [31], and open in the surface of the epithelium, however they are fewer in number than in the mare.



Figure 4. Non-pregnant camel uterus. Note that the left horn (LH) is longer than the right (RH) and there are two corpora lutea (arrows) on the left ovary. - To view this image in full size go to the IVIS website at www.ivis.org . -

In the gravid uterus the left uterine horn, in which the fetus implants, becomes noticeably distended at around 1.5 months of pregnancy and is almost double its size by 2 months at which time the uterus hangs into the abdominal cavity. By 150 days the diameters of the gravid and non-gravid horns are nearly 4 times their original sizes [29,32], the endometrium increases in size and the glands become more numerous.

The non-involuted post-partum uterus hangs over the brim of the pelvis. The uterine wall is thickened, oedematous, non-resilient and in the early postpartum period the uterus contains a small amount of old blood [32]. The uterus returns to its normal non-pregnant position between 20 - 45 days after parturition [33,34].

The Cervix - The cervix of the dromedary has between 3 and 6 annular muscosal folds but its consistency does not differ significantly from that of the uterus, unlike that of cattle, which makes it very difficult to identify by rectal palpation. In camels the cervical canal varies between 4 - 6 cm in length and 3.5 - 6.1 cm in diameter during follicular activity, but these decrease slightly during ovarian inactivity [27]. The cervix protrudes caudally in the vaginal cavity forming a fornix of variable depth (1 - 1.5 cm) [35]. The size of the protruded vaginal portion of the cervix and the actual position within the vaginal cavity varies from animal to animal and the appearance of the external cervical os varies according to the stage of the cycle. In the presence of a mature follicle the cervix is contracted and oedematous and appears open on vaginal examination. During the luteal phase, it becomes dry and the cervical os is usually covered by a flap of the last two cervical rings. During pregnancy the cervix becomes very tight and in the advanced stages the cervix is pulled forward and downward beyond the pelvic brim. The normal size and position of the cervix is regained within the first two weeks following parturition.

The Vagina - The vagina is some 25 - 30 cm in length [2] and is lined with many longitudinal folds. The anterior vagina and the vestibulum are separated by a strong band of tissue (vestibulum sphincter muscle) and the hymen [26]. This structure is very tight in nulliparous or young animals and can make manual examination of the vaginal cavity very difficult.

The Vulva - The vulva opens directly below the anus and measures 6 - 7 cm in length [2,17]. During the follicular phase oedema of the vulva can be present but it is very discrete, however, during the last week prepartum it becomes much more relaxed and oedematous. The clitoris is very small and there is no distinct clitoral fossa. The urethra is also short and the opening of the urinary meatus is small.

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