Reproduction in camels

A review

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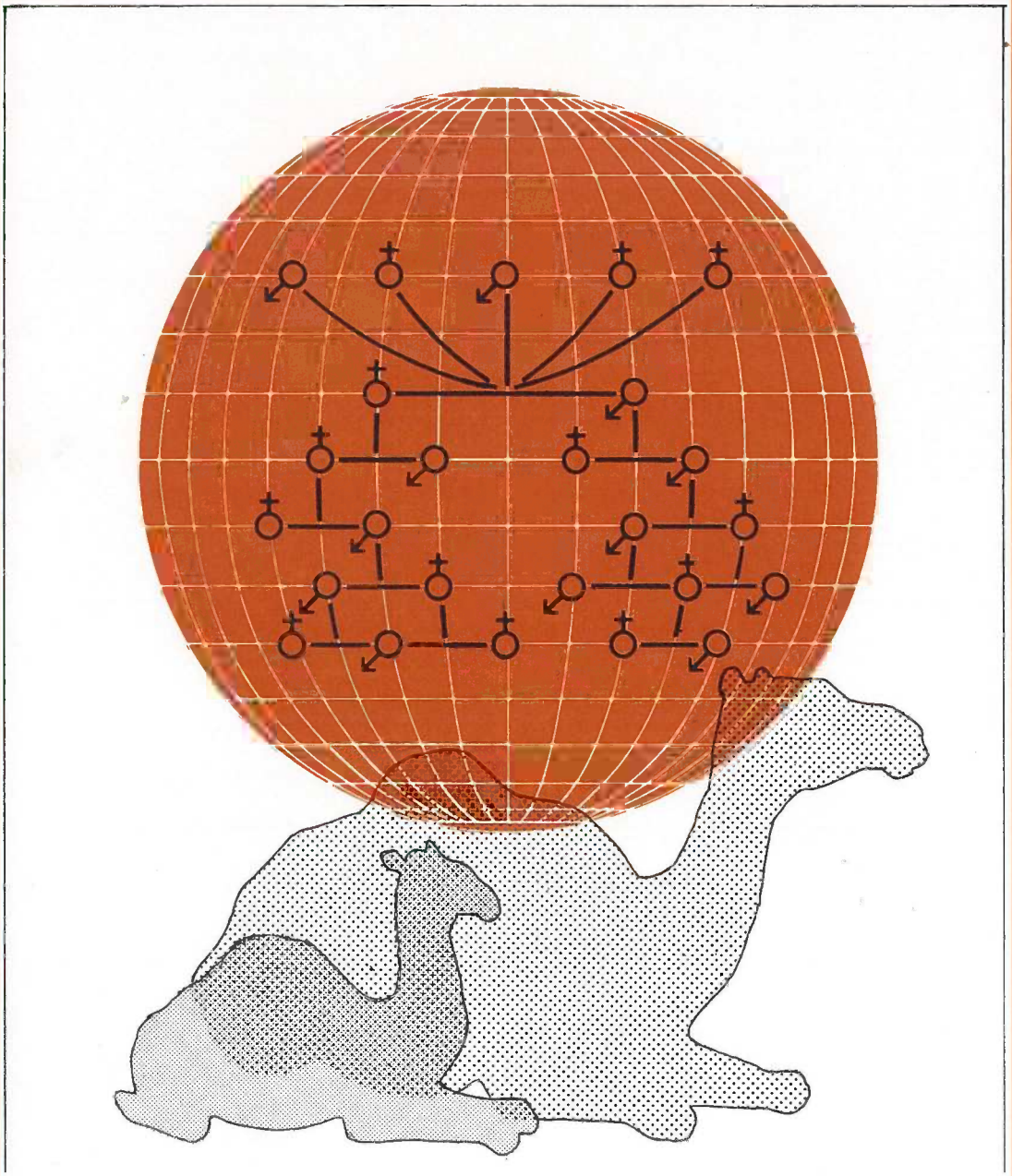

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A review

H. Merkt, D. Rath
School of Veterinary Medicine,
Clinic for Andrology and AI of Domestic Animals,
Hanover, Federal Republic of Germany

B. Musa
University of Khartoum, Faculty of Veterinary Science,
Khartoum North, the Sudan

M.A. El-Naggar
Assiut University,
Faculty of Veterinary Medicine,
Department of Obstetrics, Gynaecology and AI,
Assiut, Egypt

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FOREWORD

The camel species have long been neglected by science. Consequently, people whose lives are bound up with the camels, although having a thorough traditional knowledge of their animals, have often lacked the more precise information which can be offered by scientific study. The combination of new scientific insights and traditional knowledge and experience has been the foundation of much animal improvement in other species. The neglect of camels is perhaps due to their more limited distribution and less accessible locations.

The camel is a most valuable animal which contributes effectively to the welfare of people in harsh and difficult environments. It is frugal in habits but nevertheless highly productive of milk, meat, wool and work. Without doubt, the camel could contribute more widely and with improved management could improve the lot of those already keeping them.

Reproduction is often the key to improved livestock performance. Reproduction in the camel is not as well understood as in more common species of domestic animals. This publication is, therefore, likely to be of considerable interest and value to scientists, to camel owners and those who seek to support them through extension and other services.

The authors write with authority and bring to the subject the benefits of their own research and a thorough knowledge of the studies of others, as shown by the excellent bibliography. As a team they also demonstrate the benefits of cooperation between scientists from developing and developed countries. They have given us a concise, up-to date and comprehensive publication for which many will be grateful.

C O N T E N T S

Contents (Cont'd)

Contents (Cont'd)

CHAPTER 1

ANATOMY AND PHYSIOLOGY OF REPRODUCTION

1.1 Male organs (Authors: M.A. El-Naggar and D. Rath)

1.1.1 Scrotum and testis

The scrotum lies high in the perineal region, as in the dog or the boar, not pendulous as in the bull or the ram (Fig. 1). However, in a few cases the scrotal sac is somewhat elongated and consequently the testicles are situated in a similar manner to those in the bull. A faint line, representing the raphe scroti, divides the scrotum into two parts. Each testis is separately situated in its own compartment which is sparsely covered with hair (Yagil, 1985).

The testicles are oval in shape and lie obliquely with their long axes running cranioventrally (Osman, 1975). Both testes have limited mobility and normally they present a soft consistency (El-Jack, 1970). El Wishy & Omar (1975) investigated the correlation between age and size of the testes. At three years of age, when puberty starts, each testis varies in length from 7 to 10 cm and averages 90 g in weight.

From three years on male camels have an average testicle size of 9.1 x 5.1 x 4.3 cm and an average weight of approximately 92 g.

Normally the right testicle is smaller than the left one due to an enlarged pampiniform plexus on the left side (El-Jack, 1970, 1980; Yagil, 1985). Abdel-Raouf & Owaida (1974) and Abdel-Raouf et al. (1975) found a marked increase in testicular weight, dimensions and volume of the testis between the ages of 5 and 10 years. In aged animals these parameters appeared to be stable. Seasonal changes in testicular size have been observed by Williamson & Payne (1978). During the rutting season an increase in size occurs.

The tunica albuginea gives off several trabeculae that divide the parenchyma of the testis into lobules. These trabeculae converge centrally and merge with the mediastinum testis (Fig. 2) which extends along the proximal three fourths of the testis (El-Jack, 1980). Abdel-Raouf et al. (1975) measured the diameter of tubuli seminiferi and described a seasonal effect. In winter, during rutting, the average diameter was 218 um and during summertime it was 196 um. The authors could not find differences between left and right testicles. They also concluded that the numbers of mature Leydig cells (compared to the number of the pre-Leydig cells) increased by the end of winter such that, during the spring, the interstitial cells were mainly of the mature type. Degenerative changes with diminished numbers of mature cells were observed in the summer and this trend continued into early and mid-autumn (Hemeida et al., 1985 d).

The number of germ cells per gram tissue in the camel testis is less than in other animals (Osman & El-Azab, 1974). Yagil (1985) mentioned a seasonal effect on the number of spermatogonia, spermatids and spermatozoa. He also observed seasonal differences in sperm production which were well correlated to the activity of the tubuli seminiferi. Maximum spermcell production (8.1 x 10 spermcells/g) per day was observed towards the end of spring. Towards the end of summer only half of this value was produced. However, complete aspermatogenesis does not occur (see 4.3.3).

Singh & Bharadwaj (1978) also described seasonal changes in the spermatogenetic cell system and observed a continuous spermatogenesis throughout the year. Continuous spermatogenesis with only some seasonal fluctuations were also observed by Osman et al. (1979) and Osman & Plöen (1986).

1.1.2 Epididymis and ductus deferens

As in other species the epididymis has three parts: head, body and tail. Tingari & Moniem (1979) distinguished histologically three epididymal regions. They showed different histochemical reactions in those parts and also differentiated the middle segment into a proximal, intermediate and distal region. The epididymal ligament makes a very tight connection between the testis and the epididymal tail.

The histological and the histochemical characteristics of the different regions of the epididymis of the adult Egyptian camel are studied in detail by El Azab et al. (1983). They found changes in the histochemical activity correlated with the rutting season. Ayoub et al. (1983) described the regional histoenzymological differences of the epididymis and related them to the maturation and storage of sperm.

The body of the epididymis accounts for almost 50 percent of the total epididymal weight (Fig. 4). It differs from other species in the fact that spermcells are predominantly stored in the body itself (Wilson, 1984) (Fig. 6 and 7). El Wishy & Omar (1975) determined the spermatozoal content of the paired testes and epididymae to be about 6.3×10^9 spermcells.

The ductus deferens is very long and opens directly into the colliculus seminalis (El-Jack, 1970). In camels the seminal colliculus is of the fibro-glandular type such as in the bull and pig. The seminal colliculus shares secretory functions with the prostate and also prevents oozing of semen from the ductus deferens (Shehata, 1980).

1.1.3 Male accessory glands

The camel has a prostate, two ampullae ductus deferentis and two bulbourethral (Cowper's) glands but no seminal vesicles (Ali et al., 1978) (Fig. 5). The prostate gland consists of a massive body which is discoid shaped and is located on the dorsal aspect of the pelvic urethra (Yagil, 1985) and a small disseminated part. The parenchyma is arranged in lobules made up of irregular units lined with one layer of simple columnar

secretory epithelium with sporadic basal cells. The pelvic urethra is glandular. The cells of the glands are of the mucous type. The bulbourethral glands are almond shaped and are located on either side of the terminal portion of the pelvic urethra (Yagil, 1985). They exhibit three types of secretory units, one of which is considered as highly active (Ali et al., 1978).

The terminal end of the ductus deferens is enlarged to form an ampulla. Peripheral, central and submucosal glands open directly into the lumen of the ductus deferens. Ampullary glands probably secrete carbohydrate-protein complexes (Ali et al., 1978).

1.1.4 Penis and prepuce

The fibroelastic penis of the camel is about 60 cm long (Leese, 1927). The diameter decreases from the root towards the glans penis. It can be compared with an old-fashioned telescope (Mobarak et al., 1972; Yagil, 1985). It is directed backwards when flaccid. In contrast to the bull, the camel has a pre-scrotal sigmoid flexure that lies ventral to the cranial border of the pelvic bone. Lateral to the caudal convexity of the flexure is the site where the M.retractor penis is inserted into the tunica albuginea. The size of the corpus cavernosum penis is small and no penile septum exists (El-Jack, 1970).

Along its ventral aspect the spiralled glans penis is curved giving it a hook shape. A well defined neck is present and the bulk of the glans penis is formed by a cartilaginous tube which does not reach the free end. The external urethral process is in the form of a slender, but inflexibly sharp process (El-Jack, 1970, 1980 (Fig. 5 and 17).

Externally the penis is covered by a triangular shaped sheath, the prepuce, which opens to the rear. Backwards of the sheath are four vestigal teats. Because of the backwards facing sheath, the male camel urinates towards the rear (Fig. 8 and 9), but erection of the organ for copulation is accompanied by the effects of powerful protractor muscles which withdraw the sheath. Thus in erection the penis is directed forward (Wilson, 1984) (Fig. 17).

The sheath (external prepuce) is dark in colour and possesses two pockets, one internal and one external (Tayeb & Transblin, 1948). Its orifice is very narrow. Contraction and relaxation are controlled by three groups of muscles (Mobarak et al., 1972) which are organized into four to six bands.

1.2 Male physiology and sexual behaviour (Authors: M.A. El-Naggar and D. Rath)

1.2.1 Puberty and senility

Puberty in the male camel occurs between 3 to 4 years of age (Novoa, 1970; Chen & Yen, 1984 a). However, males reach their full reproductive potential at 5 to 6 years of age. By 15 to 20 years of age, reproductive potential declines.

1.2.2 Seasonal changes

The camels are only sexually active for a few months each year, the so called rutting. The time of the rutting season differs from region to region (see Table 1). Arthur et al. (1985 b) believed that a stud male is capable of mating at any time of the year, while Curasson (1947) is of the opinion that the sexual activity depends on the food supply. However, this was not found to be the case in zoo animals (Gauthier-Pilters & Dagg, 1981). Rutting may occur throughout the year at the equator, because there are no marked seasonal differences in temperature and photoperiod (Yagil, 1985).

Changes in weight of the testicles, corresponding to age and season, are described by several authors (Volcani, 1952; Charnot, 1964; Abdel-Raouf & Owaida, 1974; Abdel-Raouf et al., 1975). These variations are correlated with the number of spermatozoa in the epididymis (Volcani, 1952, 1953) and with the circulating testosterone levels (Yagil & Etzion, 1980). These parameters reach their maximum levels from late December to the end of March.

The seasonal changes in the activity of the male accessory glands of the adult one-humped camel have been studied by Mosallam (1981), Kandil et al. (1983) and Youssef et al. (1984). They found that both the structures and the histochemical content of the male accessory glands show markedly pronounced seasonal alterations. There is an inactive phase during summer and full activity during winter.

Badawy & Youssef (1982) measured the fructose and citric acid levels in different parts of the male genital organs. Badawy et al. (1982) observed a marked decrease of fructose and citric acid levels in castrated animals in which the glands showed a decreased activity in comparison with intact animals.

Charnot (1958) showed that the levels of 17-Keto-steroids were much higher in spring than in summer. Moreover, the neurosecretory cells of the anterior pituitary gland are more active during the rutting season than during the rest of the year (Santini, 1964). This supports the results of Charnot & Racadot (1963), who found a hyperactivity of alpha-LH secreting cells and beta-FSH secreting cells of that organ. Ismail et al. (1985) described the histological and the histochemical structure of the pars distalis of the pituitary of the one-humped male camel. The pattern of seasonal variation in cell frequency and activity of this gland has been studied by Hemeida et al. (1985 a). They concluded that higher incidence and activity of the gonadotropins during the mating season in spring support the hypothesis that day length is the primary factor controlling the reproductive cycle in this species.

1.2.3 Sexual behaviour

Normally camels are tame and calm animals. During the rutting season both males and females become more aggressive. The robust and vigorous males are called "winter rutters" and they dominate over the so-called "summer rutters". Their breeding activity lasts for 50 to 100 days.

Table 1 : Geographical variation in the breeding season with some known or inferred climatic and nutritional data at the Onset of breeding (after WILSON, 1984)

Male rut	Females in heat	Area	Source	Climate	Nutritional Status
Nov	- Mar	India	MATHARU 1966	Daylength decreasing then increasing	Depending on level of nutrition but specified
Nov	- Feb	India	SINGH and PRAKASH 1964		
Oct	- Mar	India	KHAN and KOHLI 1972		
Dec	- Feb	India	JOSHI, VYAS and PAREEK 1978	Increasing daylength	
Dec	- Mar	Pakistan	YACIN and AL WAHID 1957		
Mid Jan - end May		Turkestan	ABDUNAZAROU 1970	Very cold becoming warm: rapidly increasing daylength	Probably poor, at least in early period
Jan	- Feb	Iran	ISLAMY 1950	'Only when weather is cold': rapidly increasing daylength	
Jan	- Mar	S.Israel	VOLCANI 1952	Cool to warm; rain	Short growing season
Mar	- Apr	Egypt	ABDEL-RAOUF and EL-NAGGAR 1964	Increasing daylength warm to hot	
Mar	- May	Egypt	SHALASH and NAWITO 1964		
Spring		Egypt and Sudanese camels	OSMAN and EL AZAB 1974		
Nov	- Apr	S.Tunisia	BURGEMEISTER 1974	Daylength decreasing then increasing; rain; cool to warm	Fairly good
Dec	- May	Morocco	CHARNOT 1963 a	Daylength decreasing then increasing;	Fairly good
Nov	- Apr	Morocco	CHARNOT 1963	Cool to hot	
Aug	- Sept	Mali	SWIFT 1979	Daylength decreasing; rain	Good
Feb	- Mar	Mali	SWIFT 1979	Daylength increasing; warm to hot	Depends on winter conditions
	June	Somalia	LEESE 1927	Daylength static	Good
Sept	- Nov	Somalia	LEESE 1927	Daylength slowly decreasing	
Jun	- Sept	Australia	McKNIGHT 1969	Daylength increasing	

The sexual activity of the younger and weaker "summer rutters" starts when the activity of the "winter rutters" decreases. Males of about the same physical conditions usually start fighting each other by biting the legs of the opponent and the loser is not allowed to enter the herd (Chen & Yuen, 1984 a).

When the male becomes sexually aroused, the lips become wet with foaming saliva (Fig. 15). The teeth grind continuously and a typical sound is uttered (Chen & Yuen, 1984 a).

The one-humped camel extrudes the soft palate, the dulaa (Fig. 14 and 16), makes a bubbling sound and bends his head slightly backwards to display the bushy hair under his chin (Yagil, 1985). The dulaa arises from the oroventral portion of the soft palate and is filled with air from the trachea. In the rutting season it extends up to 36 cm in length (Charnot, 1963; Arnautovic & Abdel-Magid, 1974). Two-humped (bactrian) camels do not have a dulaa.

The legs are often spread apart. The penis is rhythmically beaten with the tail and urine is sporadically splashed on the tail and whisked on the back (Yagil & Etzion, 1980) (Fig. 8 and 9). Urine of rutting males contains a high concentration of testosterone, probably together with pheromones.

Male camels have two tubulo-alveolar glands (poll glands) in the occipital region (Fig. 13). The poll glands are present at birth (Singh & Baradwaj, 1978; Yagil, 1985).

During the period of high testosterone levels, the poll glands secret a coffee-coloured and acrid smelling fluid that seems to attract the female (Charnot, 1964). The androgen concentrations in the fluid of the poll glands are exactly the same as in the blood (Yagil & Etzion, 1980). During copulation the secretion is at maximum and it runs freely down the back of the neck.

Wilson (1984) reported changes in the blood composition during rutting. A significant decrease in hemoglobin and an increase in white blood cells have been statistically confirmed.

1.2.3.1 Copulation

The male in rut searches for the female in heat. He smells first the female genitalia (Fig. 11), shows a flehmen (Fig. 12) and bites the female in the genital area, hump and neck, often causing bleeding wounds. The restless animal extrudes the dulaa with roaring sounds and forces her on the neck to lie down or bites her in the stifle-joints. If she refuses, he might force her with great violence, often causing wounds and even fractures.

Copulation takes place in a sitting position. The male camel moves over sitting female until his front legs are on either side of her shoulders. The male flexes all joints of the hind legs in a dog-like sitting position behind the female (Fig. 16). Then he pushes himself

slowly forward until his genitalia are near hers and the tip of the penis, now directed cranially, is searching for the vulval cleft. The penis is rotated until the tip enters the vulva and is inserted into the vagina. Some owners help at this stage. The male makes several pushing movements with resting phases in between. He drools and grunts all the time. The female flexes her head repeatedly towards the male's head. The female squeals and grunts continuously (Yagil, 1985).

Joshi et al. (1980) and Abdel-Raouf & El-Naggar (1964) stated that copulation lasts on an average for about 11 to 24 minutes. These observations are similar to those of Singh & Prakash (1964) and to Burgemeister (1975) who found that it lasts usually from 10 to 20 minutes. But it might be extended for up to one hour (Droandi, 1915).

Wilson (1984) described one complete act comprising three or four separate entries. And if allowed, a male may spend the whole day with one female until he is finally exhausted and unable to stand.

Abdel-Raouf & El-Naggar (1976) stated that the length of coitus showed statistically insignificant monthly variations. But the camel exhibits libido and mounting only during the breeding season and thus semen collection was only possible from late autumn to early summer.

After copulation the male slips sideways off the female.

Depending on herd size, virility of the male and management, the following service rates are mentioned:

5 to 7 times	)	(Watson, 1969)
30	) per season	(Asad, 1970)
80	)	(Williamson & Payne, 1978) (cited by Yagil, 1985)

It is often observed that other females surround the copulating pair and lie beside them and that another female may also try to mount the couple.

Mating between dromedary and bactrian camels is possible but with danger:

Male dromedary - female bactrian:	He may injure her second hump.
Male bactrian - female dromedary:	The male's legs are too short to reach the female genitalia and he may lose his balance and injure himself. (Gauthier-Pilters & Dagg, 1981).

Both camelus dromedarius and bactrianus have the same number of chromosomes (2 n = 74). Hybridisation is possible and used in Asian countries such as Pakistan or Afghanistan (Fischer, 1987, pers. communication). Hybrids between Dromedarius and Bactricus are called Tulu.

1.3 Semen collection and characteristics (Authors: M.A. El-Naggar and D. Rath)

1.3.1 Semen collection

Semen collection can be made satisfactorily by using a bovine artificial vagina, with a length of about 40 cm and a double collection tube (Rakhimazhanov, 1975). Abdel-Raouf & El-Naggar (1964) used a "bull vagina" Danish type. Also the Hannover-type of artificial vagina was used successfully.

The jacket is filled with warm water of +38 or +39 degrees C. The rubber entrance is coated with vaseline. An airpump is coupled to the vagina. The collection glass should be protected against light.

For the semen collection a she-camel in heat is indispensable. To minimize chance of injury, the teaser must be presented in the kneeling position, eventually muzzled and with her front legs tied.

The artificial vagina can be held between the female's hind legs (Abdel-Raouf & El-Naggar, 1964) or the prepuce can be directed laterally to the artificial vagina which is held beside one of the female's hind legs (Chen & Yuen, 1984 a) (Fig. 16 and 17).

Erection occurs simultaneously with kneeling of the male and the penis can be directed into the artificial vagina by deviating the prepuce with gentle pressure (Fig. 18). The rotation of the penis is easily observed through the jacket.

Several phases of movement and rest are noticeable.

Ejaculation occurs in fractions which are wheyish and opaque in appearance. Fractions are emitted during series of penile strokes which are moderated with rest phases.

1.3.2 Electroejaculation

Electroejaculation is another possibility to collect semen from camels. Tingari et al. (1987) stated that this method is most valuable in rutting males because of their behaviour which may endanger the semen collector.

The authors used a 12 Volt battery connected to an electric ejaculator. After protection of the eyes with cushions and a proper restraint of the animal, the probe was applied rectally. While controlling muscular contractions of the animal, electric impulses are applied for 10 seconds each time. The animals reacted violently by falling on the side and kicking, and had to be restrained by about 7 people. Ejaculation occurred after 5 minutes of manipulation. Except for a reduced semen volume, all other parameters were found to be equal to those of ejaculates collected with the artificial vagina.

We produced similar results using 35 Volts and a maximum of 150 mA for 1 to 2 seconds only. The violent response of the animals was diminished by application of a tranquilizer (1.5 ml of Domosedan = Detomicine chloride).

1.3.3 Semen characteristics

Yagil (1985) estimates a daily spermcell production of 8.1 x 10^6 at the end of spring which drops to 4.2 x 10^6 spermcells per day at the end of summer.

The morphological changes of the spermatozoa, occurring during their passage through the epididymis of the camel, have been studied by Mansour et al. (1982). They found that the percentage of tailless spermatozoa was significantly higher in the cauda than in the caput epididymis. The percentage of spermatozoa with cytoplasmatic droplets was significantly higher in the caput than in the corpus or cauda epididymis.

In epididymal spermatozoa of the camel acid phosphatase is primarily localised in the cytoplasmatic droplets. In these organells the enzyme activity appears to decline with epididymal transit (Abdou et al., 1983). The acid phosphatase activity of the tails increased during the epididymal sojourn. This may reflect maturation changes.

The morphology of the camel spermatozoon is similar to that of the ram. It is generally smaller than that of other domestic animals (Fig. 20 and 21). The head is short and narrow (5.6 x 2.9 um). The acrosome is shorter than that of the bull spermatozoon. The middle piece is about 7.3 um long and the main and end piece of the tail are 34.2 um long. The total length of the camel spermatozoon is nearly equal to that of the horse (47.2 um) (Abdel-Raouf & El-Naggar, 1965). These measurements are similar to the one reported for epididymal spermatozoa (Osman & Plöen, 1986).

The volume of the ejaculate varies from 5 to 22 ml (Wilson, 1984). Abdel-Raouf & El-Naggar (1976) reported an average volume of about 8.5 ml. The volume is large when compared with that of other ruminants which possess all types of accessory glands. Perhaps the well developed prostate may be responsible for this compensation as in the dog.

The semen has a light grey to milky white colour (Fig. 19). Directly after collection, the ejaculate has a jelly-like consistency, but it changes to become aqueous in consistency after an average time of 7 to 8 minutes. Abdel-Raouf & El-Naggar (1976) found a significant difference in the liquefaction time between summer and winter.

Sperm concentration also differs, being highest during winter time (0.763 x $10^6/mm^3$) and lowest during summer time (0.176 x $10^6/mm^3$). As already mentioned, this coincides with the testicular changes associated with the rutting time. Abdel-Raouf & El-Naggar (1976) reported an average number of about 0.4 x $10^6/mm^3$, showing significant monthly variations.

Because of the absence of seminal vesicles, the pH is alkaline (approximately 7.8). Other seminal components that are not investigated in routine work, such as acid and alkaline phosphatase, were analysed by Abdel-Raouf & El-Naggar (1976).

El Manna et al. (1987) analysed seminal plasma for fructose (23.5 mg/ml), citric acid (9.8 mg/ml), total protein (775 mg/ml) and lipids (87 mg/ml). The principal source of fructose and citric acid seems to be the corpus of the prostate. Only a very small amount was detected in the pars disseminata of the prostate and the bulbourethral gland.

El-Naggar & Abdel-Raouf (1977) identified a number of 14 protein fractions in the camel seminal plasma, with varying percentages. Twenty free amino acids were also separated by use of thinlayer chromatography. Glutamic acid and alanine are present in relatively high concentrations.

El-Naggar & Abdel-Raouf (1976) studied the activity of seminal plasma acid and alkaline phosphatase enzymes and found the highest activity in February and the lowest values in March.

The average percentage of live sperm was about 55 percent. There are highly significant monthly variations with averages higher than those reported by Khan (1971).

Chen et al. (1984) investigated the possibility of inducing ovulation by seminal plasma. They have found that ovulation cannot be induced by manual stimulation of the vagina and the uterus as is the case in the cat and the rabbit, nor by the presence of spermatozoa. The authors showed that the seminal plasma contains an ovulation-inducing factor that is very stable for a long time when stored in the freezer. It was demonstrated that 1 ml of seminal plasma was sufficient to induce ovulation (see 1.5.4).

A study of the seminal fluid of different species showed that seminal plasma of the bull contains an ovulation-inducing factor for the camel and that this factor is not present in semen of boar and ram (Chen et al., 1984).

1.4 Female organs (Authors: B. Musa and H. Merkt)

1.4.1 The ovaries

The ovaries in the non-pregnant dromedary camel are oval, flattened and lobulated organs (Fig. 24). The size and shape of the ovaries vary with their content of follicles and corpora lutea (Abdalla, 1960; Musa, 1969; Wilson, 1984; Arthur et al., 1985 a; Yagil, 1985). Elongated narrow ovaries or semi-circular ones are not uncommon. The surface of the ovary is irregular. The irregularity is mainly due to the presence of multiple small follicles or the presence of corpora lutea. The colour of the ovary ranges from light red to various shades of pink.

The size and weight of the ovaries are affected by the age, the size of the animal and the stage of the reproductive cycle (Yagil, 1985); in general the ovaries measure about 3 cm in length, 2 cm in width and just less than 1 cm in thickness (Abdalla, 1965). Slight variations from these measurements were reported: 3.5 x 3.0 x 1.5 cm (Wilson, 1984), 4.0 x 2.5 x 0.5 cm (Arthur et al., 1985 a) and 3.3 x 2.9 x 1.3 cm (Yagil, 1985). The weight of the ovary depends to a large extent on the contents. The non-functioning ovary weighs about 4 to 5 g (Abdalla, 1965; Musa, 1979 b; Wilson, 1984). Ovaries with Graafian follicles or corpus luteum of pregnancy may weigh 5.5 g and 8 g respectively.

The two poles and the free border of the ovary are slightly convex. The medial border of the ovary is concave forming a hilus which is not very deep. Each ovary has a well developed ovarian ligament extending from the dorsal part of the broad ligament close to the end of the horn to a well defined hilus in the ovary.

The mesosalpinx and the mesovarium together form a very well developed bursa which closely invests the ovary (Arthur et al., 1985 a). Medially there is an opening in the bursa which leads to the fimbriae.

The ovaries of non-pregnant camels are situated in the caudal part of the lumbar region, i.e. just in front of the pelvic brim (Abdalla, 1960) or may be inside the pelvic cavity (Musa, 1969). In all cases examination of the ovaries is an important part of the gynaecological examination but they are often difficult to find. On many occasions they were found hidden beneath the uterus, so unless the uterus is retracted and rolled from side to side the ovaries would be missed (Higgins, 1986). In the bactrian camel the ovary is flat and somewhat elliptical in shape. In the absence of follicles and corpus luteum, the length, width and thickness of the left ovary are 3.2 to 3.5 cm, 2.1 to 2.5 cm and 0.8 to 1.4 cm respectively; those of the right ovary are 2.8 to 3.5 cm, 2.2 to 3.0 cm and 0.6 to 1.2 cm. They are located on the lateral side of the anterior end of the uterine horn, in the vicinity of the anterior brim of the pubis (Chen & Yuen, 1984 a).

1.4.2 The Graafian follicles

Graafian follicles when present are randomly distributed over the surface of the ovary. The presence of an active corpus luteum does not prevent the development of new follicles. This is particularly true at the beginning and at the end of gestation. Graafian follicles may grow to an ovulating size of 1.5 - 3.0 cm in diameter and project well through the surface of the ovary. Major sized follicles - up to 9 cm - can be observed exceptionally (see Fig. 23) (Yagill, 1985). The mature follicle can easily be detached from the ovary by gentle digital pressure applied to its attachment. The follicle has a thin and vascular wall. The follicular fluid is at first yellowish and later red (Musa, 1969; Arthur et al., 1985 a).

The time taken by the Graafian follicle to reach its full mature size varies considerably among individuals and even in the same animal during subsequent cycles. On the average the Graafian follicle takes 6

days to reach its maximum size with a range of 2 - 14 days. After reaching maturity, the follicles maintain their size for about 13 days (range 5 - 19 days). Then they regress in 8 days (range 7 - 10 days) (Musa & Abu Sineina, 1978 b). The growth of follicles to maturity alternates between the two ovaries, but smaller follicles can always be palpated alongside the leading follicles.

The period from the beginning of the development of the Graafian follicle until it reaches maximum size and its regression is referred to as follicular wave rather than oestrous cycle (Shalash, 1980).

In the bactrian camel the Graafian follicle is round in shape, it projects nearly wholly over the surface of the ovary. The average size is 1.7 cm with a range of 1.1 - 2.4 cm in diameter. The follicular wave or the follicle cycle in the bactrian camel lasts 14 to 24 days with an average of 19 days. It was also found that in 90 percent of the cases a new follicle will start to develop within 5 days of the initial degeneration of the old follicle. In a few cases some follicles started to regress abruptly at the 6th - 8th day when they reached a diameter of 1.0 - 1.5 cm, only to be replaced by a new follicle (Chen & Yuen, 1984 a).

1.4.3 The corpus luteum

The corpus luteum of the camel was seen only during pregnancy and in very few cases with patent os uteri (Shalash, 1965; Musa, 1969; Wilson, 1984; Arthur et al., 1985 a; Yagil, 1985). The corpus luteum of pregnancy is either spherical, elongated or oval (Fig. 25). At the beginning of pregnancy the corpus luteum is soft and appears brownish on section with a central blood clot. In the later stages of pregnancy the thecal layer becomes whitish opaque concealing the colour of lutein mass, so that the intact corpus luteum appears grey, bluish grey or whitish grey.

The young corpus luteum can be detached from the ovary by digital pressure exerted at its base. The mature corpus luteum is a compact sphere and is difficult to detach from the ovary by finger pressure.

There can be as many as three corpora lutea at one time (Shalash, 1965; Musa, 1969; Yagil, 1985). The size of the corpus luteum is given as 1.5 to 2.3 cm) (Musa, 1979 b), 1.85 to 1.88 cm (Shalash, 1965) or 2.6 cm (Arthur et al., 1985 a). The weight of the corpus luteum is 4.5 - 4.69 g (Shalash, 1965) but higher weights of the order of 6 - 9 g have been observed (Musa, 1979 b).

In the bactrian camel the corpus luteum forms 1 to 2 days after mating. The mature corpus luteum is similar to a mature follicle in shape, size and connection with the ovary. It takes 5 to 10 days for the corpus luteum to develop to mature size and this is maintained for 3 days. If no conception follows the ovulation, it will regress in 10 to 12 days (Chen & Yuen, 1984 a).

1.4.4 The oviducts

The oviduct in the camel is 17 - 28 cm long (Abdalla, 1967; Musa, 1969; Novoa, 1970; Wilson, 1984). The isthmus is less coiled than the ampulla and the ovarian part of the fallopian tube. The lumen of the ampulla is about 5 mm in diameter at its ovarian opening in the depth of the fimbriae. The lumen of the isthmus is 1 - 2 mm in diameter. Each oviduct opens into the uterine horn by a narrow orifice at the summit of a papilla 3 - 4 mm in height (Novoa, 1970). The oviducts are enlarged at the uterine end, possibly allowing prolonged storage of large numbers of spermatozoa (Wilson, 1984).

1.4.5 The uterus

The uterus of the camel is bicornuate and is large enough to occupy a position which is partly abdominal and partly pelvic. It has a well developed uterine body from which the two horns diverge and taper anteriorly to give a combined uterine shape intermediate between that of the letters T and Y (Fig. 22/23). The endometrium shows irregularly raised mainly longitudinal folds which are more conspicuous in the right horn, and internally there is a clear median septum (Shalash, 1965; Musa, 1969; Novoa, 1970; Wilson, 1984; Arthur et al., 1985 a; Yagil, 1985). The uterine tubes are 22 - 24 cm long (Arthur et al., 1985 a) or 13 - 15 cm long (Musa, 1969). The average uterine weight during follicular activity was found to be heavier than during the ovarian inactivity being 284.06 and 272.38 g respectively.

In the bactrian camel the uterus is bicornuate and T-shaped. A septum about 6 cm in length separates the two horns posteriorly. The left horn is longer even in the new born and is about 8 - 12 cm. The mucosa is smooth or has chequered folds, but no caruncles.

1.4.6 The cervix, vagina and vulva

The cervix is a short structure that tends to protrude for a short distance in the vagina. The average length and diameter of the cervical canal during the follicular activity are 5.32 and 5.96 cm respectively while during the ovarian inactivity the length and diameter are 4.96 and 5.79 cm respectively (Shalash, 1965). There are about 5 annular mucosal folds in the cervix (Arthur et al., 1985 a).

The vagina is an elastic organ, reddish in colour and 30.55 cm long. There are both longitudinal and circular mucosal folds in the vaginal wall. The canals of Gärtner are large and the Bartholin glands are also well developed, originating in the region of the external cervical opening (Wilson, 1984; Yagil, 1985).

The vulva and vestibulum. The vestibulum is about 8 cm long. Chen & Yuen (1984 a) recorded for the bactrian camel a length of the vulvar cleft of 5.5 cm. The clitoris is small. The urethra is short and the opening of the urinary meatus is small. In the central floor of the vestibulum there is a suburethral diverticulum, on top of which the urethral orifice is located. The hymen or its remnants mark the separation between the vestibulum and the vagina (Wilson, 1984; Yagil, 1985).

In the bactrian camel the cervix is 5.0 - 6.5 cm in length and 4 cm in diameter. It has 2 to 5 ring folds on the mucosa. It protrudes 1.0 - 1.5 cm in the vagina. The vagina is 25 - 30 cm long. The vulva is 6 - 7 cm in length. The clitoris is very small (Chen & Yuen, 1984 a).

1.4.7 Mammary glands

The udder has four quarters (Fig. 28); the front two are separated more distinctly from each other than they are from the two smaller hind quarters. The teats are small and have three small openings each (Wilson, 1984).

1.5 Female physiology and sexual behaviour (Authors: B. Musa and H. Merkt)

1.5.1 Endocrinology

There is little information on endocrinology in camels. Elias et al. (1984 a) determined the peripheral blood levels of progesterone in a total of 26 female camels during various reproductive stages within a period of 2 years. A rise over 1.0 ng/ml could only be observed in 4 pregnant animals of the total in question 2 to 5 days after mating. In non-pregnant animals the level of progesterone never exceeded 0.55 ng/ml. In the pregnant animals the progesterone dropped until day 30 to 1.32 $\pm$ 0.2 ng/ml and increased to a peak of 8 ng/ml until day 150.

During the rest of the pregnancy the level decreased until parturition. The authors attribute the decrease of the progesterone level from the peak in the first week of pregnancy until day 30 to the presence of a functional Graafian follicle during early pregnancy in the camel. Shalash (1965) showed that the CL does not inhibit follicular growth in pregnant camels.

Elias et al. (1984 b) measured the estradiol (E_2) concentration in the serum of a total of 23 dromedaries during the various reproductive stages. During the oestrous cycle they found that concentrations were between 9 and 110 pg/ml. The peak level of 74.7 $\pm$ 6.61 pg/ml was maintained for 2.9 $\pm$ 1.83 days, the length of an oestrous cycle being 17.2 days. In the 10th month of pregnancy the level rises abruptly to 338.3 $\pm$ 162.42 pg/ml and continues to rise until the 12th month, peaking at 606.0 $\pm$ 120.27 pg/ml. The hormone concentration drops from that time on until the day of parturition to 113.4 $\pm$ 26.51 pg/ml. The level of E_2 is low (6 - 48 pg/ml) during the non-breeding season.

1.5.2 Main features of the oestrous cycle in the camel

The camel is a non-spontaneous ovulating animal and in this respect it is incorrect to apply the term "oestrous cycle" as it applies to spontaneous ovulators such as the cow and the mare.

The ovarian activity during the "cycle" is follicular (see 1.4.2). Graafian follicle(s) will develop in one or both ovaries reaching a mature size. If no copulation occurs it will regress and then another follicle

will start developing. Usually the left and right ovaries function equally and keep alternating in activity throughout the breeding season.

It is more appropriate to refer to such pattern of activity in the ovary as follicular wave. This could be divided into four phases:

a) The growing follicular stage, equivalent to prooestrus.
b) Mature follicular stage, equivalent to oestrus or heat.
c) Atretic follicular stage if mating did not occur.
d) The non-follicular stage or lag phase.

Studies carried out on slaughter house material in Sudan (Musa, 1969), Egypt (Shalash, 1965) and Saudi Arabia (Arthur & Al-Rahim, 1982) indicated that the camel is a polyoestrous breeder. However, there are certain months in the year of the season where the ovarian activity is very low, while in other months the ovarian activity is very high.

1.5.3 Duration of the follicular wave

The duration of the follicular wave (the oestrous cycle) varies slightly in relation to geographical locations. In India the mean length of the cycle was 23.4 days (Joshi et al., 1978). In Egypt it was 24.2 days (Wilson, 1984) and in Sudan it was 28 days (Musa & Abu Sineina, 1978 b). Oestrus lasts about 4 to 6 days in general. The prooestrous phase lasts about 6 days and the atretic phase lasts 7 to 10 days (Musa & Abu Sineina, 1978 b).

In the bactrian camel the duration of the cycle averages 19 days (range 14 to 24 days), the prooestrous or developing phase lasts 5 days (Chen & Yuen, 1984 a).

1.5.4 Ovulation

Ovulation in the camel occurs normally after the coitus and in this respect it resembles e.g. the cat and the rabbit (Jöchle, 1975). It is known that in these animals the neuroendocrine reflex involving the initiation of luteinising hormone release is delayed until coitus occurs. However, manual stimulation of the cervix for 15 minutes in the camel did not induce ovulation but only partial luteinisation of the intact Graafian follicle (Musa & Abu Sineina, 1978 b). Ovulation occurs 32 to 40 hours after copulation under the influence of luteinising hormone (LH) (Wilson, 1984; Yagil, 1985).

In the bactrian camel ovulation also takes place within 36 to 48 hours after coitus. However, Chen & Yuen (1984) found that only the deposition of a minimum of 1 ml seminal plasma in the vagina or the uterus is required for ovulation to occur. Spermatozoa could not induce ovulation. Intramuscular administration or luteinizing hormone (LH), human chorionic gonadotrophone (HCG) and luteinizing hormone-releasing hormone (LH-RH) produced ovulation in a similar manner to that of seminal plasma (Chen et al., 1984) (see 1.3.3).

1.5.5 External signs of heat or oestrus

The behavioural changes during heat in the female camel are much less drastic than the changes in the male camel. The signs of heat in the female include restlessness, bleating, vulval swelling and mucous vaginal discharge. The tail is moved up and down in rapid succession on the approach of the male or when hearing its gurgling voice (Fig. 10). The vagina at this stage is moist and pink coloured although the degree of wetness decreases as heat progresses. The cervix is relaxed and moist. Rectal palpation will reveal that the uterine horns are turgid (Musa & Abu Sineina, 1978 b; Wilson, 1984; Arthur et al., 1985 a; Yagil, 1985).

In the bactrian camel the cervix becomes softer during oestrus admitting one finger. The vagina is slippery but no mucus is expelled from the vulva (Chen & Yuen, 1984 a).

Elias et al. (1985) induced oestrus in 7 camels during the last part of seasonal anoestrus by injecting 7000 i.u. PMSG. However, they got the impression that the induced oestrus was followed by an inadequate luteal function, because pregnancies were not maintained by day 60 after mating.

1.5.6 Female sexual behaviour

The sexual behaviour of the female camel is involved to a great extent with events in the ovary and the uterus. When she is on heat she exhibits the behaviour characteristics of the camel as has been mentioned before. The external manifestation of heat in the camel is related to the status of the sex hormones in the blood. The peaks in hormone (estradiol) are quite regular and are found to be 28 days apart.

In the normal oestrous cycle the progesterone concentrations are low, below 1 ng/ml (Yagil, 1985). At range, the rutting male pursues the oestrous female and on catching up with her, presses his head on her neck and induces her to sit down for copulation (see 1.2.3.1).

When the animal becomes pregnant it is no longer receptive to males. During the last trimester of pregnancy it becomes lazier and tends to move slowly.

1.6 Pregnancy and foetus (Authors: B. Musa and H. Merkt)

1.6.1 Site of pregnancy

The right and left ovaries seem to function equally in the camel. In spite of this fact it is observed that 99 percent of pregnancy occurs in the left uterine horn. Anatomically the left horn is slightly bigger than the right one (Musa & Abu Sineina, 1978 a; Wilson, 1984; Arthur et al., 1985 a) (Fig. 23). In the bactrian camel 96.49 percent of foeti were found in the left horn (Chen & Yuen, 1984 a).

1.6.2 Embryonic migration

Embryonic migration from the right horn to the left horn is very frequent and it seems that this is always the case when ovulation occurs in the right ovary and not in the left. Considering the site of pregnancy and the equal functioning of the two ovaries, this brings the incidence of egg migration close to 50 percent (Musa & Abu Sineina, 1978 a; Arthur et al., 1985 a).

1.6.3 Multiple ovulations

Multiple ovulations in the camel are possible, These are represented by multiple corpora lutea in the ovaries. The incidence of presence of multiple corpora lutea ranges from 12.5 to 14.7 percent (Musa & Abu Sineina, 1978 b; Wilson, 1984). Most of these (about 13.65 percent) are double corpora lutea. In spite of the occurrence of multiple ovulations in the camel, the incidence of twinning is very low (about 0.4 percent). This indicates high losses in ova or early embryonic death.

1.6.4 Follicular activity during pregnancy

The presence of the corpus luteum of pregnancy does not completely prevent growth and development of Graafian follicles. The latter were seen in 4.8 percent of pregnant camels (Wilson, 1984). However, the incidence was higher during early pregnancy and decreased with advancing gestation until very close to parturition. The incidence of follicular activity during pregnancy in Sudan was 10.38 percent from 491 specimens examined (Musa & Abu Sineina, 1978 b).

1.6.5 Foetal fluids

The total quantity of foetal fluid in the camel is very small, averaging 9 litres at term. The allantoic fluid represented 80 - 90 percent of this throughout the gestation period. The amniotic fluid does not exceed one litre. The amniotic fluid remains watery in consistency throughout the gestation period. At parturition there is a well developed separate membrane that encloses the foetus. This membrane is very slippery when wetted with the amniotic fluid. This greatly facilitates the act of parturition in the camel. The specific gravity of the allantoic fluid increases progressively throughout gestation while the specific gravity of the amniotic fluid usually drops during the last third of gestation. Hippomanes are seen in both fluids (Musa & Abu Sineina, 1976 c; Arthur et al., 1985 a).

In the bactrian camel the amniotic fluid at full term is 700 - 900 ml and the allantoic fluid is 6500 - 1150 ml (Chen & Yuen, 1984 a).

1.6.6 Placenta

The placenta in all camelidae is diffuse and epitheliochorial in nature, without cotyledons (Wilson, 1984). In the camel there are three foetal membranes rather than the classical two membranes in the cow and the mare. These are:

a) amnion membrane;
b) allantoic membrane;
c) epidermal membrane. This membrane is unique in the camel.

It is epidermal in origin and it becomes visually apparent when the foetal length is 41 cm and until the end of gestation. It completely encloses the foetus except for the following openings to the amniotic fluid: at the lips, genitalia, anus, teat orifices and hooves of the foetus. At birth this membrane comes with the foetus while the other two foetal membranes pass out during the third stage of parturition (Musa, 1977) (Fig. 31/32).

The epidermal membrane was also observed in the bactrian camel (Chen & Yuen, 1984 a). In the South American camelids this membrane also exists as a transparent structure which becomes parchment-like when it is dried. We found it in a new-born Guanaco (Lama guanacoë) in the Hannover Zoo (Merkt et al., 1987).

1.6.7 Presentation

The posterior presentations predominate from early pregnancy to a foetal body length of 41 - 50 cm at which point the situation changes to anterior presentation of 51 percent. This trend continues until almost 100 percent anterior presentation is achieved at term. However, it was difficult to change the presentation beyond the stage of 61 - 70 cm by manual manipulations (Musa, 1979 a; Arthur et al., 1985 a).

In the bactrian camel the presentation, position and posture were noted to be similar to those of the foal. Out of 20 parturitions investigated only one posterior presentation was observed: the foetus was dead and ankylosed (Chen & Yuen, 1984 a).

1.6.8 Sex ratio

The primary sex ratio does not differ from the expected unity. The ratio ranges from 1.00 - 1.28 for males to 1.00 - 1.11 for females (Wilson, 1984). Male calves have the testes in the scrotum at birth.

1.6.9 Gestation length

The literature concerning the gestation length in the camel is very conflicting compared to variations reported in other species such as the cow or the mare. The average gestation length is 390 $\pm$ 2 days (Yagil, 1985) or 375 days (Arthur et al., 1985 a) and it is commonly stated as 12 to 13 months. Male calves are carried 1 to 2 days longer. Month of calving, sire and birth weight have significant effect on gestation length (Sharma & Vyas, 1971).

In the bactrian camel the gestation length averages 402.2 $\pm$ 11.5 days (Chen & Yuen, 1984 a).

1.6.10 Prenatal losses

Prenatal losses seem to occur more frequently in the camel than in other species. This is evident from incidence of multiple ovulation (13.65 percent) and the twinning rate of only 0.4 percent (Musa & Abu Sineina, 1976 b). The reason for these losses still requires more investigation (see 1.6.3).

1.6.11 Pregnancy diagnosis

Various methods could be employed to detect pregnancy in the camel. These include rectal palpation (eventually in addition with ultrasound), laboratory methods and behaviour of the animal.

1.6.11.1 Rectal palpation

This is carried out with the camel restrained in the sitting position. The technique thereafter is similar to that employed for the cow. The findings at different stages of pregnancy could be summarized as follows:

1st month: There is at least one corpus luteum in one of the ovaries, no evident sign of pregnancy in the dromedary. In the bactrian camel palpable swelling was reported at one month pregnancy.

2nd month: The whole of the left horn is uniformly enlarged. One or both ovaries with corpus luteum. The uterus is within the pelvis. A plug of mucus closes the os uteri externum. Ultrasound shows already embryonic vesicle and foetus (Fig. 26).

3rd month: Pregnant horn obviously bigger than non-pregnant horn. It is at the pelvic brim and its corresponding ovary is in the abdomen.

4th month: Cervix is at the pelvic brim. The uterus is just in front of the pelvic brim but most of it is palpable.

5th month: Uterus is in the abdomen; a small degree of fluctuation can be noticed; foetus occasionally is detectable.

6th month: Uterus is in the abdomen with dorsal surface a little below the level of the pelvic floor. During this month and for the remainder of pregnancy the foetus can be palpated and the ovary on the non-pregnant side can be felt until the 10th or 11th month.

7th month: Uterus is in the abdomen below the level of the pelvic floor but can still be reached by hand; foetal head and forelegs can be detected.

8th month: Foetal head, neck and forelegs can be felt.

9th month: Foetal movements are observable and can possibly be balloted at the apex of the right flank. Slight udder development is possible.

10th month: Foetal movements are obvious, presentation can be determined; balloting fairly certain; udder possibly developing rapidly.

11th month: Vulva is slightly swollen. Hypertrophy of the udder is first noticed.

12th month: Abdominal enlargement clear. Almost fully developed young; caudal part of the uterus projects backwards and occupies the anterior two-thirds of the pelvis, the sacroisciatic ligament begins to relax.

13th month: Relaxation of the pelvic ligaments is pronounced (Fig. 27), tumefaction of the vulva is marked and hypertrophy of the udder is more evident (Fig. 28). The foetus can be balloted from both flanks, there is no mucal discharge resulting from the breaking of the cervical seal.

1.6.11.2 Laboratory methods

Various laboratory methods were used. Some of them were of limited success, other are lengthy or not very practical under field conditions. These methods could be summarized as follows:

1. Changes in specific gravity and the pH of the cervical mucus after 6 weeks of gestation. The specific gravity increases from 1.00 to 1.014 g and the pH from 7.05 to 8.2 (Wilson, 1984).

2. Vaginal temperature: Not useful because of the great variation in body temperature of the camel.

3. Cuboni test (oestrogen test): Was used with limited success during the second half of gestation. The technique is the same as for the mare. In connection with this it must be remembered that no inordinate growth of foetal gonads during the second half of pregnancy like that of the mare has been seen in the camel (Arthur et al., 1985 a).

4. Gonadotropin test: Presence of follicle stimulating hormone in the blood of pregnant camels could be detected using immature female mice as in the method popular for the mare. The test is positive only when the foetal body length is 11 - 58 cm. This test is of very limited practical application (Elazeb & Musa, 1976).

5. Progesterone determination: Levels of progesterone above 1 ng/ml are considered high and indicate pregnancy in the camel. This method is accurate and can be done from the second week of pregnancy (Yagil, 1985).

1.6.11.3 Ultrasound

This method is accurate from the second month of pregnancy. The probe is applied to the right flank or above the uterus per rectum (Yagil, 1985). We prefer the rectal application of the probe eventually after tranquilization of the dam (Fig. 26).

1.6.11.4 Behaviour

In literature of the past it was thought that a female if pregnant would curl up her tail and rapidly move when approached by a male. This behaviour is a false indicator for pregnancy.

In the bactrian camel the technique and the findings are more or less similar to those of the dromedary except that pregnancy could be detected as early as the 6th week. The left urogenital artery also reverberates at the end of the 7th month and the right one at the 9th month (Chen & Yuen, 1984 b).

1.7 Parturition (Authors: B. Musa and H. Merkt)

Parturition is a continuous process in the camel but it could be viewed under the four classical sub-headings:

1.7.1 Preparturient changes

These could be summarized as follows:

1. Detection of colostrum 4 to 6 days before parturition
2. Vulval labiae are swollen
3. Relaxation of the sacroisciatic ligaments starts 15 days before parturition - but two shallow grooves, one on each side and distal to the sacrum, due to the relaxation of the sacroisciatic ligaments, are clearly seen 9 days before parturition (Fig. 27).

The times given by Elias & Cohen (1986) for the premonitory signs of parturition in camels are to be seen in Table 2.

1.7.2. First stage of labour

First stage of labour is taken from the time of evidence of discomfort and restlessness shown by the animal until the first water bag appears at the vulva. This stage could be as short as 3 to 5 hours (Yagil, 1985), 7 hours (Musa, 1983) or as long as 24 hours (Arthur et al., 1985 a). The stage is characterized by restlessness, the animal lying on one side and struggling for a short period and then standing again. Straining occurs towards the end of this stage at the rate of 1 to 2 minutes. The vaginal and rectal temperature is normal.

Table 2: The premonitory signs of parturition in camels (after Elias & Cohen, 1986)

Signs	Time of appearance in prepartum period (days)
Abdominal distension	12.5 ± 4.1
Relaxation of the sacroisciatic ligament	15.5 ± 2.6
Hypertrophy of the udder	24.2 ± 8.3
Presence of colostrum	4.6 ± 2.5
Oedema of teats	1.5 ± 0.5
Oedema of vulval labia	4.0 ± 1.5
Vulval discharge	minimal, 1.5 ± 0.2

Data are expressed as means ± SE.

1.7.3 Second stage of labour

The second stage of labour is taken as the time from the appearance of the first water bag until birth is complete. This stage is characterized by continuing straining and struggling on the ground from time to time. Usually one front leg of the foetus is ahead of the other, foetus is almost always in anterior presentation (Fig. 29), in dorsal position and the head is resting on the front legs or sometimes between the legs (Fig. 30). The stage could be as short as 25 minutes (Yagil, 1985) or 30 - 40 minutes (Sharma & Vyas, 1971; Musa, 1983; Arthur et al., 1985 a).

Elias & Cohen (1986) observed a female which was suckling her own teats during the second stage of labour, which may have produced uterine contractions.

1.7.4. Third stage of labour

The third stage of labour is taken as the period from the birth of the calf until the foetal membranes are expelled. This stage is characterized by straining once every 2 - 3 minutes, rolling on the ground - rest - and rolling again. The afterbirth emerges progressively, including large quantities of retained allantoic fluid. When the animal stands this helps to detach the membranes. The stage is usually complete in 15 minutes (Mukasa-Mugerwa, 1981) or 30 - 40 minutes (Musa, 1983; Arthur et al., 1985 a) or 40 - 50 minutes (Yagil, 1985). The foetal membranes are expelled, most of the time inverted.

In the bactrian camel the pattern of the events of parturition is similar to that of the dromedary. The second stage of labour could be as short as 26.8 $\pm$ 12 minutes (Chen & Yuen, 1984 a) or as long as 40 $\pm$ 2.63 minutes (Mukasa-Mugerwa, 1981). The third stage of labour averages 49 minutes but normal expulsion was also seen to last up to 184 minutes (Chen & Yuen, 1984 a) the whole foetal membranes could leave the uterus without being inverted.

1.7.5 Involution of the uterus and the first post-partum heat

Following parturition involution occurs in 15 to 28 days with an average of 21 $\pm$ 0.5 days (Musa & Makawi, 1985). The post-partum oestrus can occur by 3 - 4 weeks following parturition (Yagil, 1985) or in 14 to 30 days (Wilson, 1984). Musa & Makawi (1985) found that the first post-partum heat is delayed until the next breeding season.

It has been shown that late in the gestation period follicles could develop and this might be the reason for the signs of heat observed immediately after parturition in some reports. Even in the female foetus follicles are sometimes found (Fig. 22). We think that such heat could be associated with low fertility because the involution of the uterus occurs only 3 to 4 weeks later. Elias et al. (1984 b) followed a post-partum female with a suckling newborn both by serial rectal palpation and by determination of the estradiol level in the serum. The first oestrous cycle post-partum occurred after 42 days and was a silent one.

In the bactrian camel, involution is complete in 25 - 30 days and the first heat occurs 5 to 35 days after parturition (Chen & Yuen, 1984 a).

1.8 The newborn (Authors: B. Musa and H. Merkt)

1.8.1 Behaviour of the newborn and its dam

The newborn calf attempts to rise to nurse in about 15 minutes after birth. The mother is quiet and very protective when handling her calf. Camels are not interested in eating foetal membranes. The umbilicus ruptures when the calf slips to the ground or when the mother attempts to get up.

The recently described third epidermal membrane (Musa, 1977; Chen & Yuen, 1984 a) is about 345 g (see 1.6.6). It comes with the foetus, dries quickly after birth and falls off.

1.8.2 Perinatal growth and mortality

The nutritional status of the dam may have a direct effect on the foetal growth in the camel. Poor nutritional levels during gestation may lead to increased perinatal mortality (Mukasa-Mugerwa, 1981). The development of the camel foetus and its associated growth curve is strikingly similar to that of the bovine (Musa, 1979 a).

Burgemeister (1974) claims considerable losses due to the consequences of inbreeding such as Arthrogryphoses, Polydaktilia etc. (Fig. 33/34).

1.8.3 Birth weight

A lot of variations exist in the birth weight reports from the different parts of the camel world. In India, birth weight varies from 26.3 to 52.15 kg with a mean of 37.23 kg. Males are slight heavier than females, 38.19 to 37.19 kg. In Tunisia and Kenya they weigh 25.18 and 30.9 kg respectively. In Sudan the calves weigh 30 - 40 kg (Yagil, 1985). The differences may originate from different kinds of nutrition, management and even breeds.

CHAPTER 2

MANAGEMENT OF REPRODUCTION

B. Musa and H. Merkt

2.1 Age of sexual maturity

Puberty in the females occurs at 3 to 4 years of age and the first calf is born when the mother is 5 to 6 years old. The female remains sexually active for 20 to 30 years (Yagil, 1985). It is a common practice to withhold female camels from breeding until they are 4 to 6 years and the age at first calving would be 5 to 7 years. Because camels can live up to 40 years, it is possible that they produce a number of calves similar to that for cows.

Yagil (1985) refers to an attempt in which prepuberal female camels, 1.5 to 2 years old, were injected with a synthetic FSH preparation; 1000 units on 3 consecutive days. They were mated and a year later normal healthy calves were born after normal parturition. The future will test the practicability of such methods.

Puberty in males occurs at 6 years of age and good service ability is maintained until 18 to 20 years (Novoa, 1970; Wilson, 1984).

In the bactrian camels puberty is reached at three years in the female, but breeding is delayed until 4 to 5 years of age. They breed for 15 years and sometimes up to 20 years of age (Chen & Yuen, 1984 a).

2.2 Breeding season

The female camel is considered to be a seasonal breeder with a marked peak in sexual activity (Wilson, 1984). In the tropics it is possible that camels, kept under high levels of nutrition and management, would show oestrus throughout the year (Arthur & Al Rahim, 1982). Factors that affect the beginning of the season, its duration and intensity of sexual activity include: local climatic conditions, nutrition and management (see 1.2.2).

Wilson (1984) summarized the geographical variation in breeding with some known or inferred climatic and nutritional data at the onset of breeding (Table 1).

In the bactrian camel the breeding season starts in January and terminates in mid-April for both females and males. The start of the breeding season may be related to increasing daylight length (Chen & Yuen, 1984 a).

Finally, it can be pointed out that the camel is a potential polyoestrus animal, however with a high adaptability to local conditions.

2.3 Conception rate

The number of services per conception for camels bred during the 1st day, 2nd day, 3rd, 4th and 5th days of oestrus were 1.87, 1.75, 2.75, 2.12 and 2.72 respectively (Gupta et al., 1968). It appears clear from this that the conception rate is better from the third day of oestrus on.

One mating per oestrus was also reported to produce 80 - 90 calves in 100 she-camels that were bred (Arthur et al., 1985 a). Breeding during the first or second day of oestrus might improve conception rates in general (Mukasa-Mugerwa, 1981). The low fertility rates reported by various investigators could be partly related to conception rates.

Burgemeister (1974) points out that parasitic and infectious diseases, as well as nutritional influences might have a negative influence on the breeding efficiency.

2.4 Calving interval

Due to gestation length and seasonality of breeding, calving in practice occurs every two years (Wilson, 1984; Arthur et al., 1985 a). However, in Kenya and in corralled camels a calf every year is possible (Yagil, 1985). The long calving interval is attributed to lengthy gestation, limited breeding season and late postpartum oestrus which is frequently one year after parturition (Mukasa-Mugerwa, 1981).

Richard (1985) observed calving intervals of 15 months, when the animals were well fed. Schwarz et al. (1983) recorded calving intervals of 28.4 months in traditionally maintained herds versus 20.9 to 22.2 months in herds with both good sanitary control and nutrition.

2.5 Weaning rate

Suckling young are usually weaned any time between 3 and 18 months. The lactation period may last up to two years. In the camel under traditional pastoral systems the average weaning age is about 13 months. The change from milk to more solid food occurs gradually and with some effect on growth. Sometimes young camels continue suckling until the next calf is born or even afterwards (Mukasa-Mugerwa, 1981; Yagil, 1985).

2.6 Calf mortality

The newborn camel is a very delicate creature. Calf mortality is very high; it could reach up to 50 percent and levels of 30 percent are considered usual. The causes of these losses are varied and complex. They include: overfeeding, underfeeding, too early weaning, ticks, camel pox, calf diarrhoea (perhaps with a viral etiology), other endemic diseases and management (Mukasa-Mugerwa, 1981; Wilson, 1984) (see also 1.8.2).

2.7 Reproductive longevity

The length of the camel's reproductive life is given as 20 to 30 years (Wilson, 1984; Yagil, 1985). Some animals with good nutrition and management can live up to 40 years of age.

In bactrian camels, the female can breed for 15 years and not uncommonly give birth when she is over 20 years of age (Chen & Yuen, 1984 a).

CHAPTER 3

PROBLEMS OF REPRODUCTION

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The problems of reproduction in the camel are not extensively investigated as for example in the bovine. The information collected on these problems is derived mainly from questioning the camel owners, slaughterhouse material and very limited clinical and farm observations.

3.1 Early embryonic mortality

The incidence of early embryonic death seems to be high in the camel. It was found that twinning occurs in about 0.4 percent of 491 single births reported by Musa & Abu Sineina (1976 a). In the same study two and three corpora lutea were found in 13.65 percent and 1.22 percent respectively. The reason for these high prenatal losses is still open for more investigation (see 1.6.10). Yagil (1985) claims that one of the causes of foetal death is the strong inbreeding in the herds.

3.2 Reproductive diseases

3.2.1 Abortion and stillbirth

These are known to occur in camels. The incidence of brucellosis in camels in different countries is given in Table 3. It seems to related to breeding and husbandry practices.

In Africa Brucella melitensis was found to be the causative agent while in the USSR the infection was found to be due to Br. abortus.

The organisms were isolated in the different countries with variable incidence of success.

It is claimed that young camels are resistant up to the age of 11 months and that they contract the disease from the dams on subsequent calving. If this is the case, then separation of young camels at 7 to 8 months of age from positive dams might help in the control programme (Higgins, 1986).

The role played by brucellosis in the overall picture of abortion in camels is not quantified. It appears that other important endemic diseases play a significant role in the overall incidence of abortion.

Trypanososmiasis leading to general debility and abortion is an important disease. Pasteurellosis and salmonellosis are also considered as causes of abortion in camels. Other causes of abortion include febrile conditions such as pneumonia and camel pox, or nervous excitement (Mukasa-Mugerwa, 1981).

Table 3: Incidence of brucellosis in camel populations in different countries (after Higgins, 1986)

Country	Infection Rate percent
USSR	15.0
Chad	3.8
Ethiopia	5.5
Egypt	10.3 - 26.0
Sudan	1.75 - 5.75
North-Eastern Kenya	14.0
Nigeria	1.0
India	1.8
Tunisia	3.8 - 5.8

3.2.2. Diseases of the female reproductive tract

Examination of abattoir material provided some information about some of the diseases that could be encountered in the reproductive tract. Although this could be considered as biased information when referring to populations of camels in general, it could however provide useful information about the existence of these diseases.

These diseases include: pyometra, bursal and ovarian adhesions, endometritis associated with a partially involuted uterus, and cystic ovarian degeneration (Mukasa-Mugerwa, 1981).

3.3 Dystocia

The incidence of camel dystocia appears to be very low (Arthur et al., 1985 a). The foetal component of dystocia includes: carpal flexion, lateral deviation of the head and hock and hip flexion. Posterior presentation is uncommon. Foetopelvic disproportion, monstrosities and transverse presentations are rare.

On the maternal side, uterine inertia occurs to a small extent.

In dealing with dystocia in the camel it was found that head and limb extension is more difficult to achieve than in the cow. However, the camel foetus survives dystocia better than the equine foetus and the camel is a good subject for caesarean section. Also foetotomy using Thygensen's embryotome is possible when necessary.

Ceasarean section could be performed on the left flank using xylazine sedation and local regional or infiltration anaesthesia.

A camel, 17 hours in dystocia, delivered a live foetus by caesarean section (Arthur et al., 1985 a).

3.4 Vaginal prolapse

This is seen clinically in pregnant camels that were well fed with limited exercise. In most of the cases it does not interfere with the pregnancy in question. The condition could be treated successfully by the Bührer technique (Arthur et al., 1985 a).

3.5 Other problems of reproduction

The fertility is defined as the ability of the male and female to produce viable germ cells, mate and conceive and subsequently give birth to living young (Mukasa-Mugerwa, 1981).

A significant aid to establish precise figures for fertility is record keeping and good management. Unfortunately both are missing under traditional camel raising systems.

Existing information indicates that fertility is unlikely to be higher than 50 percent in pastoral herds and that under improved ranch conditions it could be up to 65 percent (Mukasa-Mugerwa, 1981).

In Saudi Arabia Arthur et al. (1985 b) reported a 80 - 90 percent fertility rate and that sterility is about 1 percent. Yagil (1985) observed up to 100 percent fertility. Poor nutrition and poor grazing are a cause of reduced sexual activity in both females and males.

Debilitating diseases such as trypanosomiasis, tuberculosis, mange, pleuropneumonia and heavy parasitism all compromise the fertility rate in the camel.

Endocrine factors including insufficient gonadotropins to enhance follicular development and subsequent ovulation may also contribute to fertility rate in camels.

Concerning the bacterial flora of the female genitalia in the camel, Zaki & Mousa (1965) isolated corynebact., anthrocoids, micrococci, sarcina, gaffkya and gram negative becilli from the normal genital tract of pregnant and non-pregnant slaughtered animals. Almost the same spectrum of germs was found by Eidarous et al., (1983), however including E. coli and Staph. epidermidis.

Nawito (1973) recorded the bacteriological findings in the uteri of 2075 one-humped camels of unknown history from the Cairo abattoir. In 94 cases (4.53 percent) clinical symptoms such as asbcesses in the uterus, catarrhal endometritis, haemorrhagic endometritis, pyometra and pyometra with macerated foeti were found. Micrococcus pyogenes var. aureus played the predominant role. Furthermore, Micrococcus pyogenes var. albus, beta-haemolytic streptococci, E. coli and Pseudomonas aeruginosa could be isolated from the uteri of animals with clinical symptoms.

3.6 Reproductive problems in the male

There is very little information on reproductive problems in the male camel.

Phimosis, paraphimosis, orchitis and testicular hypoplasia were clinically observed.

Abdel-Raouf (1965) described a case of bilateral testicular hypoplasia in a dromedary. The seminiferous tubules were divided into four types according to the degree of development. Microscopic examination revealed that the smaller left testicle contained a larger number of underdeveloped tubules than the right one.

Burgemeister (1974) observed a high incidence of incest breeding in camel herds in Tunisia. It is well known that inbreeding can cause alterations in the male genital tract such as hypoplasia.

We found cases of unilateral cryptorchidism both in a live animal and in material from abattoirs (Fig. 3, 4). Furthermore, a case of subfertility was found due to pronounced asthenozoospermia in the semen of a male camel with normally developed and clinically healthy testicles.

Shawki et al. (1983) reported the incidence of filariosis among Egyptian camels to be 5 percent. The histological changes of both the testis and epididymis affected with filariosis reveal fibrosis of the tunica albuginea. The consistency of the compromised testis was soft with areas of hardness. There were degenerative changes and necrosis of the seminiferous tubules and epididymal ductus. The arterioles were thickened, dilated and engorged with microfilaria. These pathological changes were due to occlusion of the arteries and arterioles with larvae, thus reducing circulation to the testis and the epididymis. Such conditions may induce sterility in camels.

With regard to the age, the minimal incidence of testicular degeneration (10.9 percent) was found between the age of 4 - 6 years, while the maximum values (50 percent) were present in senile camels over 20 years of age. Marked decline in the blood levels of thyroxine, carotene and vitamin A were found in camels with moderate and advanced testicular degenerations. Hemeida et al. (1985 b) mentioned that there were different degrees of testicular degenerations. These changes exert a profound influence on the sperm production rate. Other testicular abnormalities mentioned by Hemeida et al. (1985 c) were: testicular hypoplasia (1.6 percent), cryptorchidism (0.7 percent), orchitis (2.3 percent), necrosis (0.7 percent), hydrocele (0.7 percent) and seminoma (0.3 percent). Filarial orchitis and funiculitis due to dipetalonema evansi was the most common abnormality (7.7 percent).

The bacterial flora of the male and female genital system of the camel has been examined by Eidarous et al. (1983). They found that Staph. epidermidis, anthracoids, E. coli, micrococci and Gaffkya were the most prevalent bacteria in the male genital tract. The prepuce and urethra were the organs most inhabited by microflora. Staph. aureus, B. proteus, Pseudomonas aeruginosa, C. bovis and streptococci were isolated only from the prepuce. The percentage of male genitalia in which no microbes were found was about 42 percent.

CHAPTER 4

RESEARCH NEEDS FOR IMPROVING CAMEL PRODUCTIVITY

B. Musa and H. Merkt

4.1 Improvement of low fertility rates

The low fertility rates in camels constitute an obstacle in camel reproduction 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 (see 3.1).

4.2 Development of an artificial insemination system

Research to develop such a system is necessary to improve on the breeding of the animal. Males could then be selected for meat qualities, milk, riding or baggage requirements. The system will speed up improvement and will help to improve management systems and in turn will feed back to improve the fertility rates. Many questions remain open such as semen collection methods, handling of the semen, development of suitable extenders, deep-freezing, etc. Yagil (1985) points out that the selection of camels, e.g. for milk production, is difficult due to the fact that they are later maturers. Choosing the best male would mean that he would be at least 14 years old before adequate data on his daughters' performance could be received. However, by 15 to 20 years of age reproductive potential declines (see 4.2.1). Long-term storage of semen could be the solution to the problem.

Time, place and semen doses for insemination are other items for future investigations.

4.3 Nutrition and reproduction

It appears that the reproductive performance in both male and female camels is dependent to some extent on the level and quality of nutrition. The nutritional components which are directly involved in this are still not clearly identified.

Research in this area is lacking in spite of the fact that its significance is felt by various investigators in camel reproduction.

4.4 Ecology and reproduction

Studies in ecology are badly needed to investigate the magnitude of reproductive problems under the existing management systems. This would help in suggesting practical alternatives that could be adopted under pastoral and/or ranch/farm conditions. Deeper understanding of camel/owner relationships is necessary for any future improvement plans for productivity. Also, such studies would throw light on existing economics

involved with camels and from the biomass contributed from camels determined strategies for reasonable offtake rates could be worked out.

4.5 Diseases and reproduction

The role of various endemic diseases and especially parasitism in compromising the reproductive process is still not quantified. Heavy parasitism for example is known to compromise productivity and reproduction, but the real losses in terms of figures are still not known. Mange, on the other hand, is a serious disease in camels and great losses are encountered as far as the productivity of hair and hides are concerned, beside having a non-quantified negative affect on reproductive performance.

4.6 Record keeping

Record keeping and reliable statistics of all reproductive problems are basic needs for any future research (Burgemeister, 1974, 1975).

4.7 Embryo transfer

This may be of interest in the near future.

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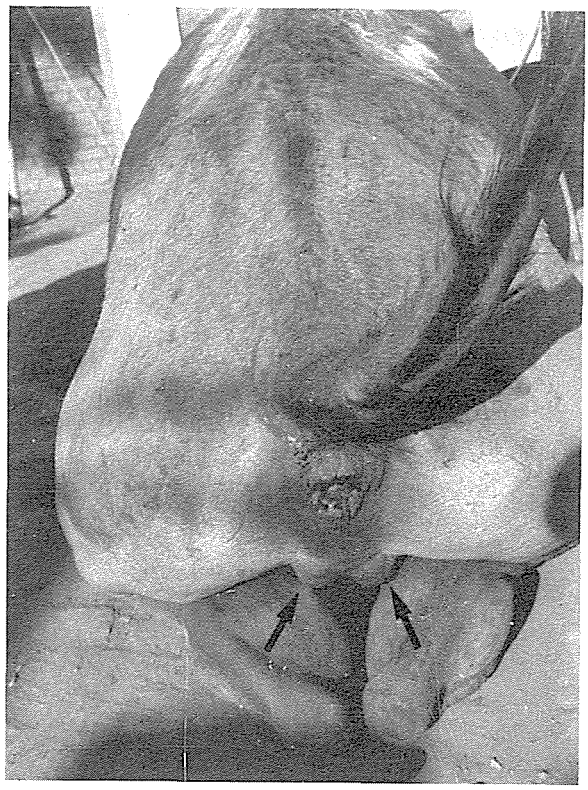


Fig. 1: Normally developed testicles in the camel (arrows).*

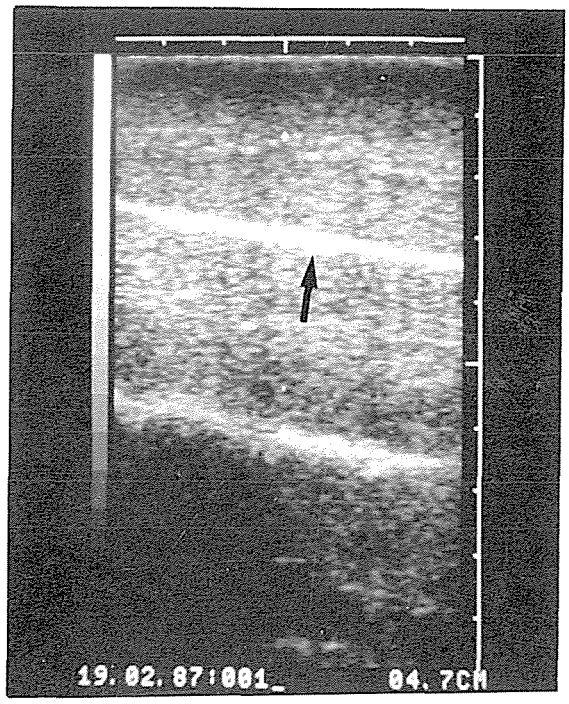


Fig. 2: Ultrasound photograph of a camel's testicle. Note the mediastinum (arrow).*

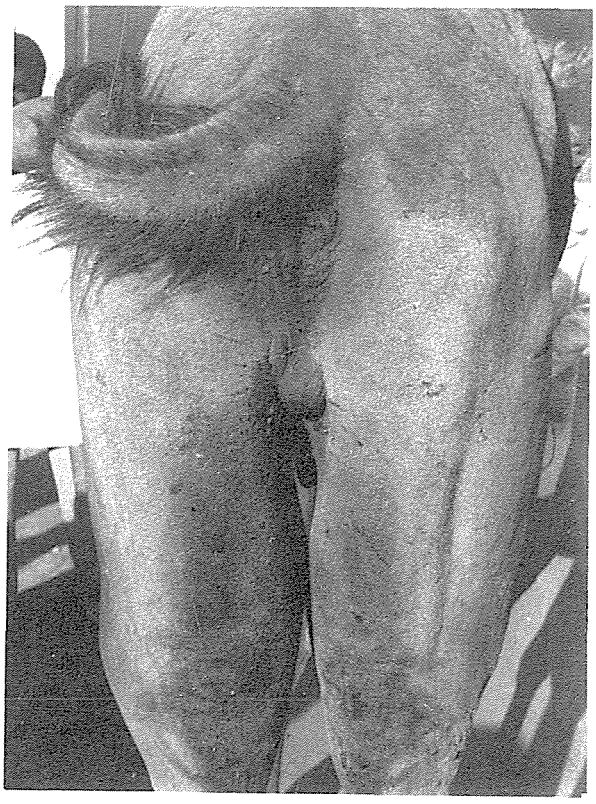


Fig. 3: Inguinal cryptorchidism of a camel's left testicle.*

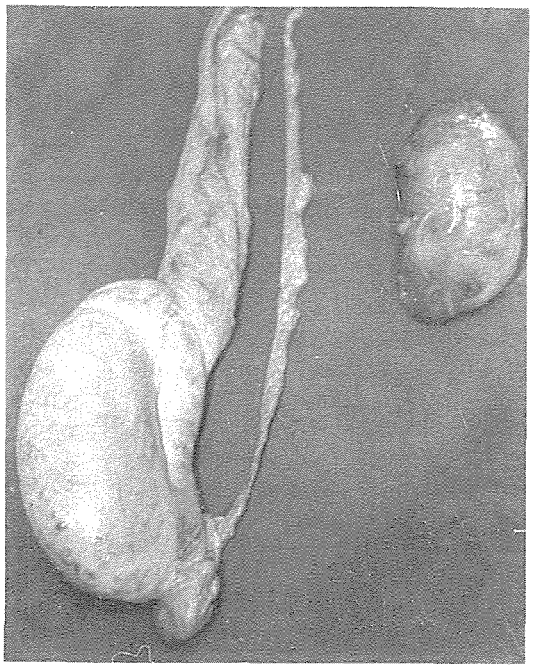
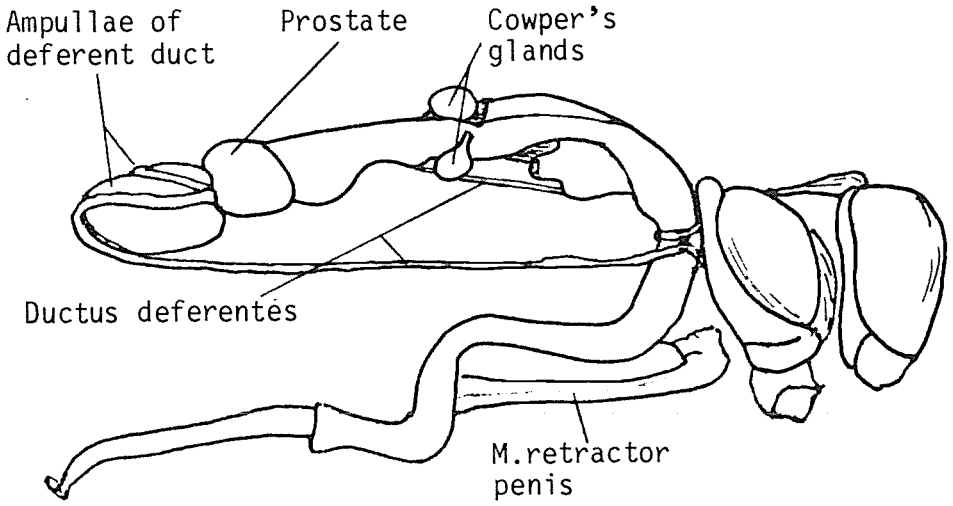


Fig. 4: Normal and inguinal cryptorchid testicle of a camel (material from abattoir). Note the large corpus epididymis of the normal testicle in which most of the semen reserve is being stored.*

Fig. 5/5 a: Male genital organs of the camel. Note the hook shaped tip of the penis.***



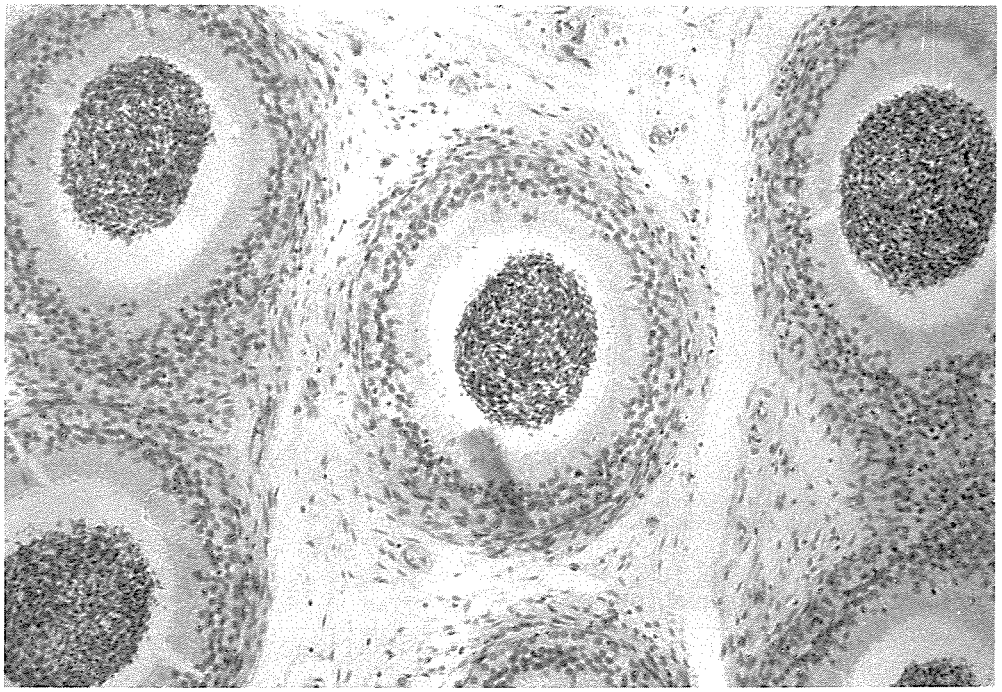


Fig. 6: Histological section of the corpus epididymis of the camel (augmentation 1:400). Note the number of sections through the coiled ductus.*

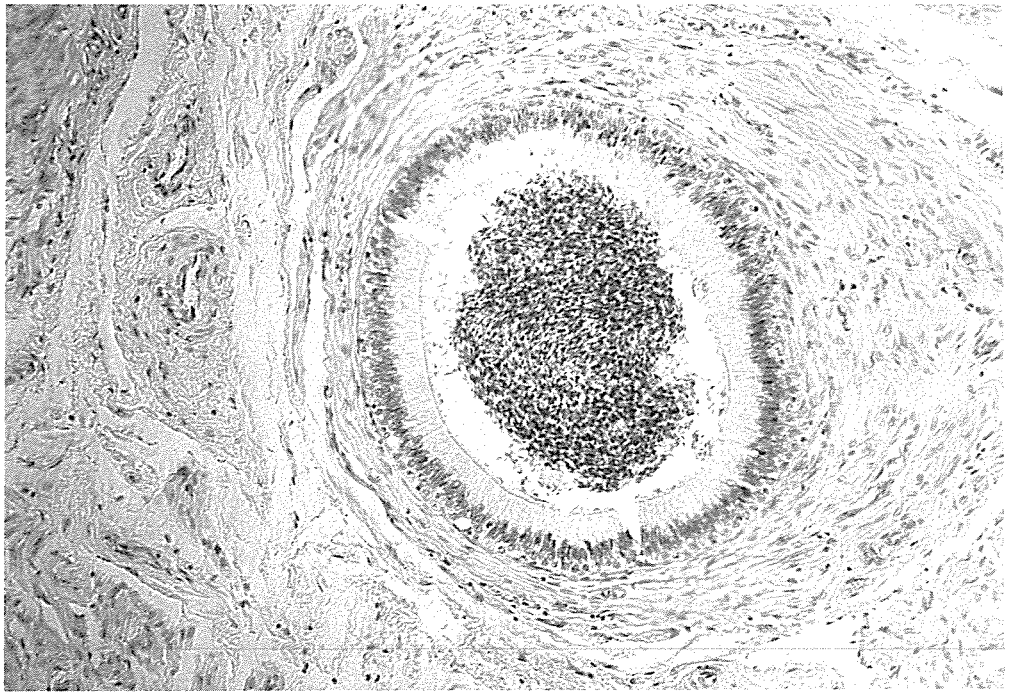


Fig. 7: Histological section of the cauda epididymis (augmentation 1:630). Note, there is only one section through the canal.*)

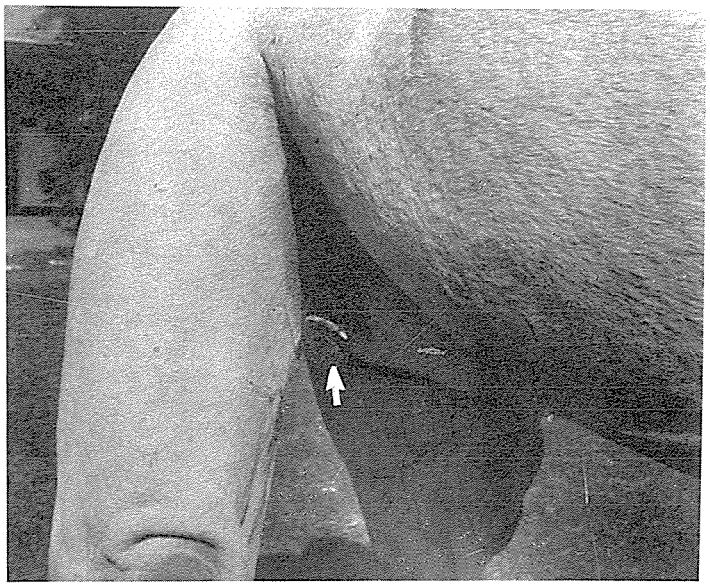


Fig. 8: Rutting male sprinkling the urine backwards. *

Fig. 9: The tail is whisking the urine around. Note the moisture on the hind legs.*

Fig. 10: Female in heat, lifting the tail and urinating.*

Fig. 11: Rutting male smelling the vulva of the female in heat. *

Fig. 12: Rutting male with "flehmen".*

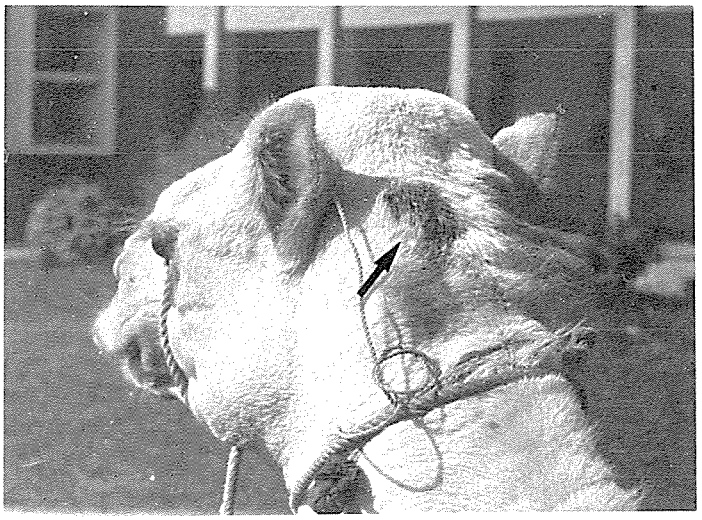


Fig. 13: Poll glands of a rutting male in secretion.*

Fig. 14: Protrusion of the soft palate, the dulaa, a typical symptom of predominantly sexual excitement in the male one-humped camel. *

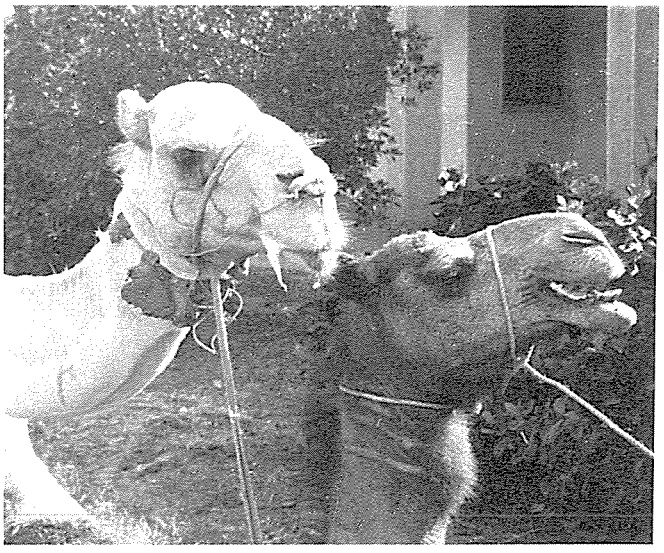


Fig. 15: Mating behaviour. Note the salivation of the male.*

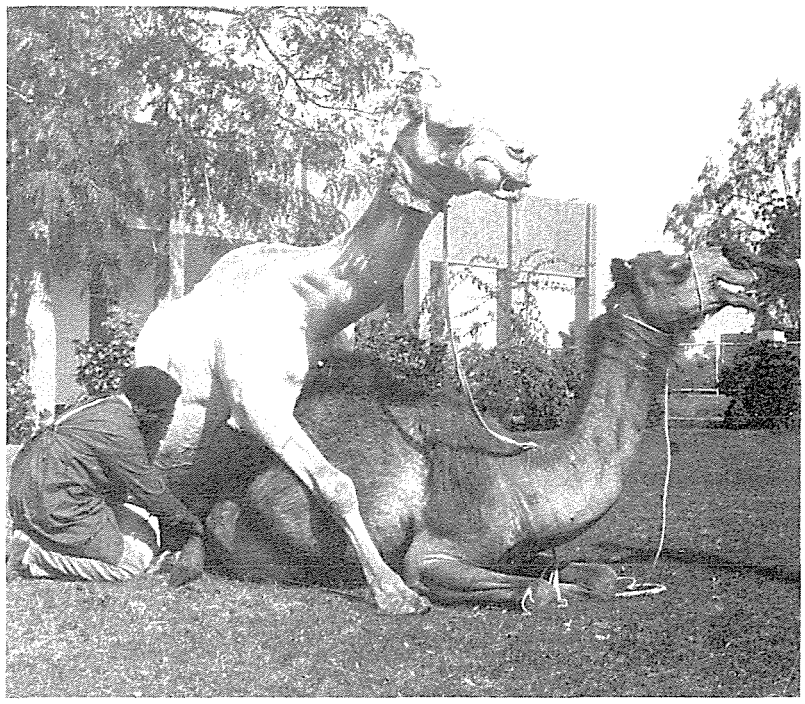


Fig. 16: Semen collection in the camel by means of an artificial vagina. Note the inflated dulaa of the male.*

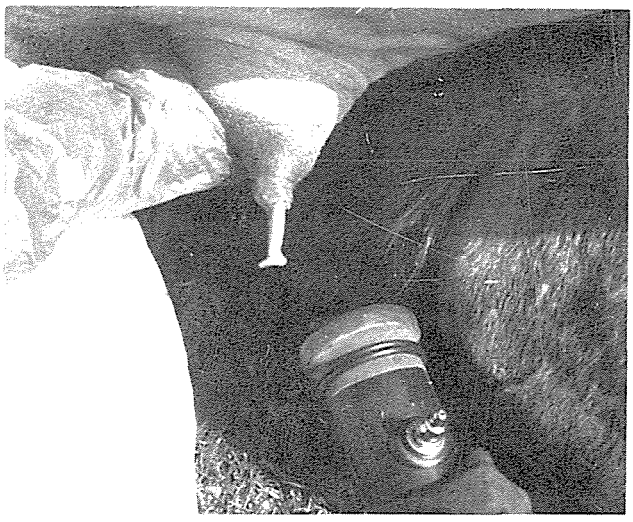


Fig. 17: Introducting the penis into the artificial vagina. Note the hook shaped tip of the penis.*

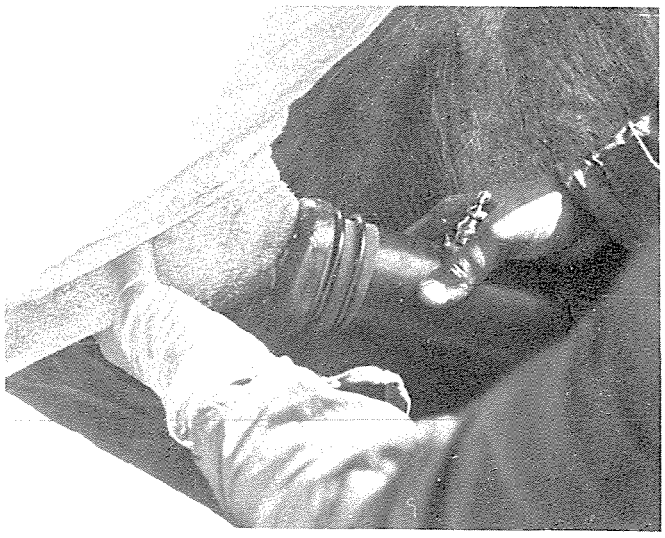


Fig. 18: Position of the artificial vagina during semen collection.*

Fig. 19: Ejaculate of a camel.*

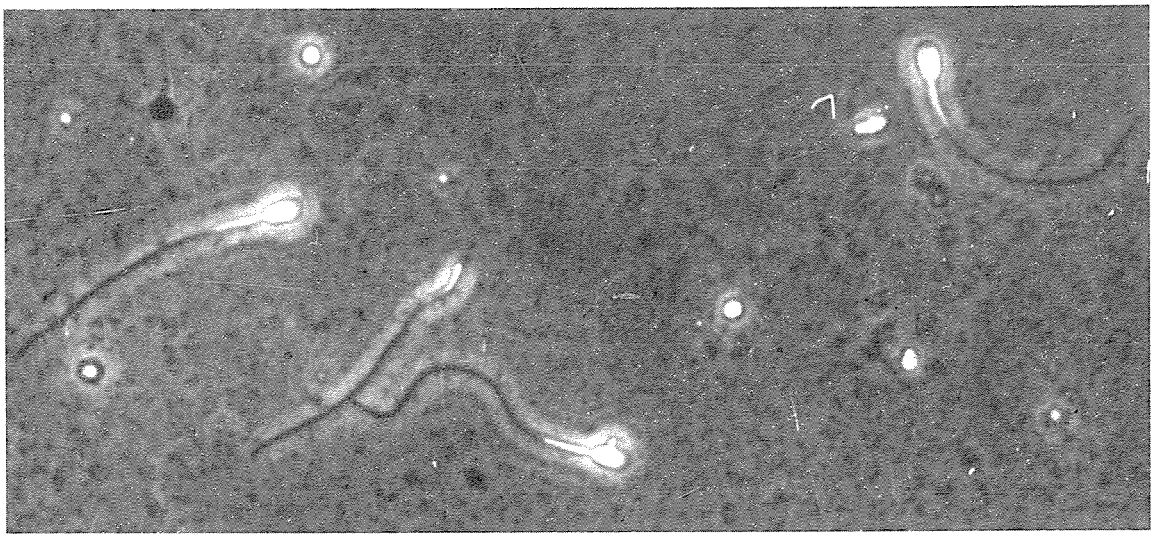


Fig. 20: Sperm cells of the camel (augmentation 1:320).*

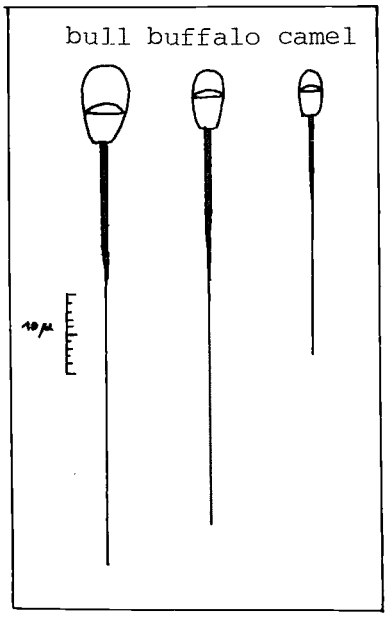


Fig. 21: Comparison of spermatozoa from bull, buffalo and camel (after Abdel-Raouf & El-Naggar, 1965).***

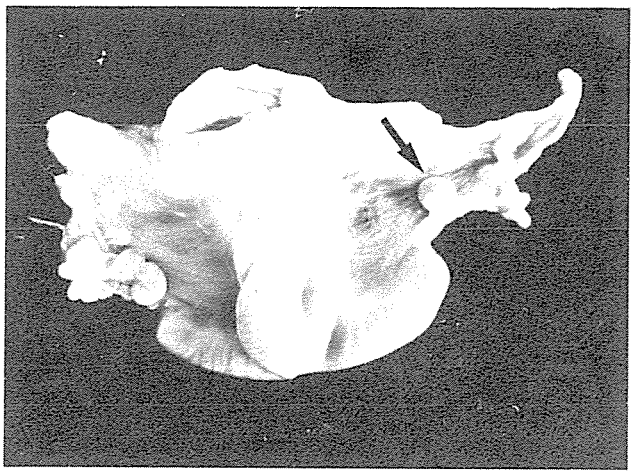


Fig. 22: Uterus and ovaries of a new born camel. Note the ripe follicle on the left ovary. **

Fig. 23: Uterus and ovaries of an adult camel. Note the size of the left horn and the ripe follicle of about 8 cm diameter on the left ovary. **

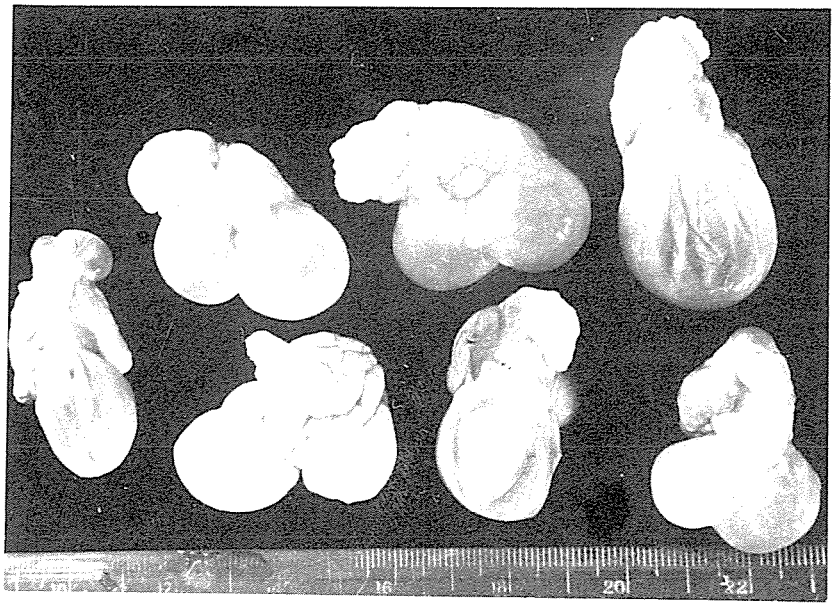


Fig. 24: Specimen of camel ovaries with different sized follicles.**

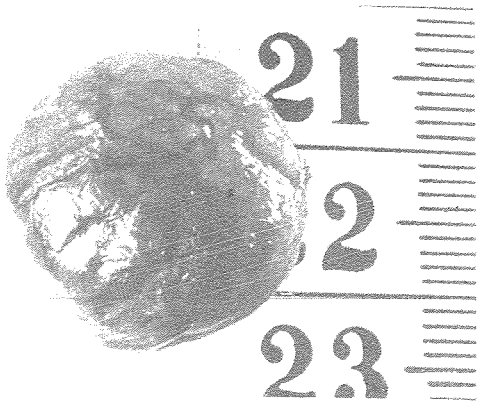


Fig. 25: Isolated corpus luteum of a camel. **

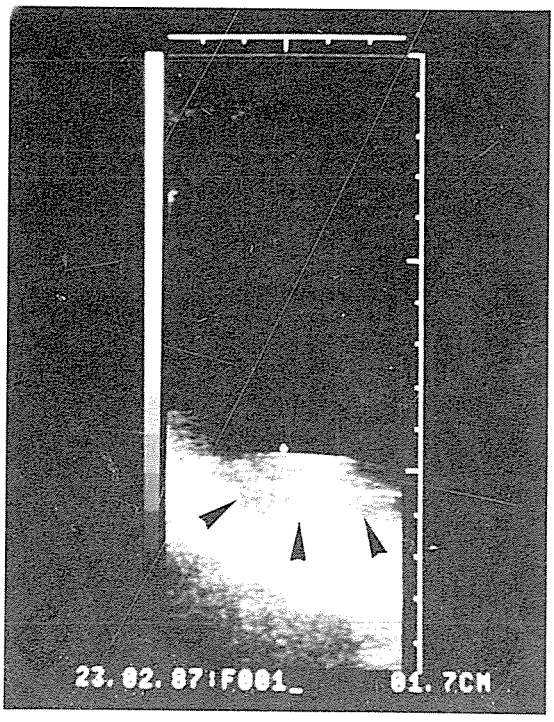


Fig. 26: Ultrasound picture of a seven weeks' pregnancy in the camel. The embryo is marked by the arrows. ****

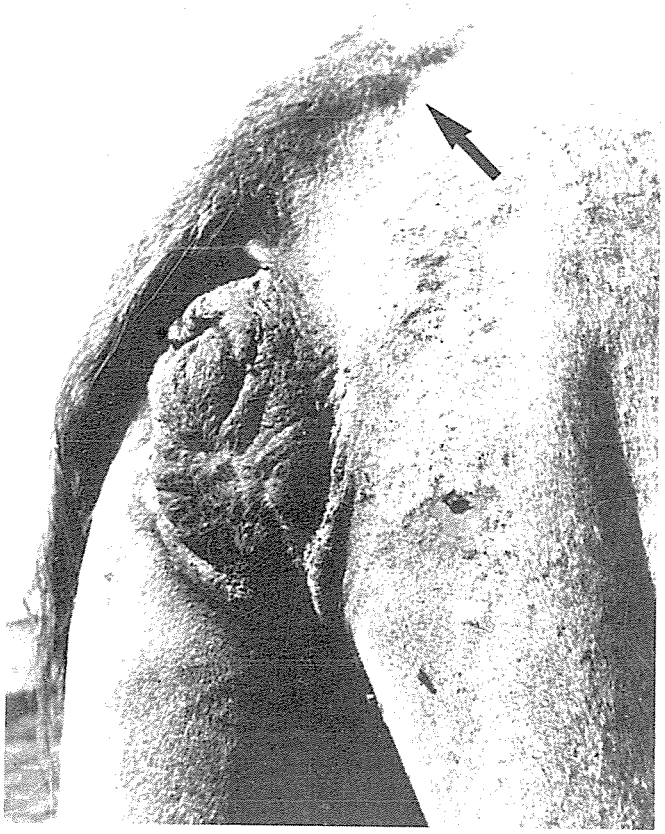


Fig. 27: Vulval labiae slightly swollen in a preparturient camel. Note the relaxation of the sacrosciatic ligament (arrow).**

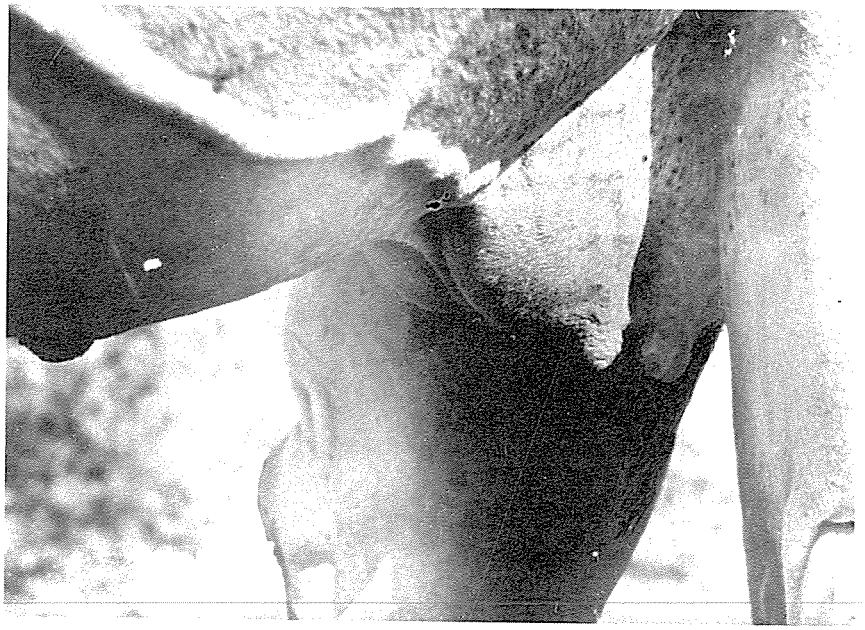


Fig. 28: Hypertrophy of the mammary gland in a preparturient camel. Note milk vein and tumefaction of the teats.**

Fig. 29: The bag is ruptured. The head and one leg appear.**

Fig. 30: Soon the foetus will slip down to the ground.**

Fig. 31: The epidermal membrane, a unique phenomenon in the camelids.**

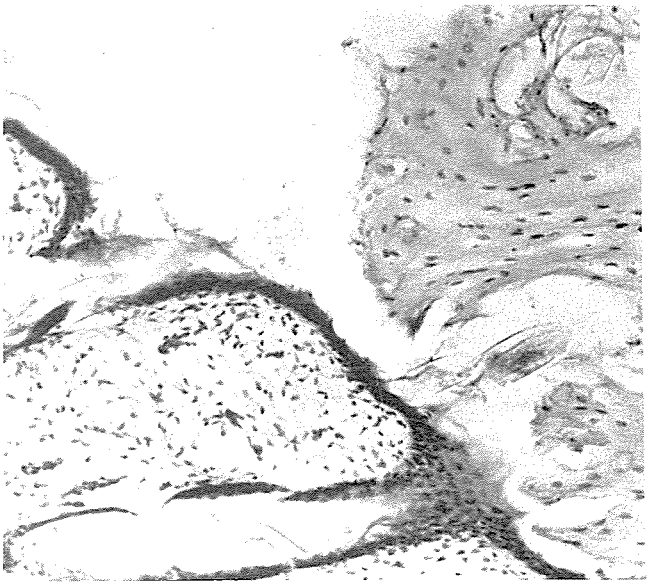


Fig. 32: The epidermal membrane (right) begins to be separated from the epidermis.**

Fig. 33: Goitre and ankyllotic legs in a camel foetus.**

Fig. 34: Polydactilia in a camel foetus, a probable consequence of inbreeding.**

* Photograph by D. Rath/Hannover
** " " B.E. Musa/Khartoum
*** " " M.A. El-Naggar/Assiut
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