Morphology of the female reproductive organs of the African lion (*Panthera leo*)

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Abstract

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The topography and splanchnology of the reproductive organs of the African lioness were studied and described *in situ* and after removal. The kidneys were located far caudally in relation to the thirteenth ribs. The suspensory ligament was very well developed, originated in a fan-like manner from the dorsolateral abdominal wall lateral to the kidney and extended up to a few centimetres cranial to the kidney. The proper ligament of the ovary as well as the round ligament was well developed. The round ligament inserted on the medial femoral fascia. The left ovary was bigger than the right. The ovarian bursa had a short mesosalpinx that did not cover any part of the ovary and the fimbriae extended along the entire length. The urethral tuberculum as well as the urethral crest were well developed. The left uterine horn was longer than the right. The uterine tube was found to open directly into the tip of the uterine horn and not onto a papilla. The reproductive organs of the lioness resembled those of the domestic cat and dog but with some major differences.

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Introduction

Currently, there is no available description of the female reproductive organs of the African lion. To perform laparoscopic sterilization of the lioness, a sound knowledge of the splanchnology and topography of the female reproductive tract is required.

Some general anatomical descriptions for the lion exist. These include: morphology of the adrenal gland (Park *et al.* 1997), gross anatomical description of the renal venous system (Abuzaid *et al.* 1993), arterial segmentation of the spleen (Abuzeid *et al.* 1989), papillae distribution on the tongue (Bhardwaj *et al.* 2000), gross anatomy of the tongue (Panchal *et al.* 1992) and gross morphology of the liver (Khatra and Singh 1987). Radiological anatomy of the normal appendicular skeleton (Kirberger *et al.* 2005a,b), histological appraisal of sterilization (Nath *et al.* 2005) and hyoid apparatus and pharynx have also been described (Weissengruber *et al.* 2002). Body dimensions have also been compiled (de Waal *et al.* 2004). The lion's skeletal muscle fibre type (IIx) and its metabolic characteristics have been studied (Kohn *et al.* 2011). Captive bred lions usually have accurate birth records and the age of free-ranging lions can be determined (Smuts *et al.* 1978a). Female African lions reach sexual maturity between 43 and 66 months of age (mean = 48 months) and all lionesses over 5.5 years of age will have ovulated (Smuts *et al.* 1978b).

Various male reproductive organ anatomical studies have been described. These include seminiferous tubules and testicular morphometry of adult African lions (de Barros *et al.* 2006), sertoli cell index and spermatic reserves in adult captive African lions (de Barros *et al.* 2007), cryptorchidism in the lion (Cohrs and Schneider 1936) and spermogram of African lions (Miya *et al.* 2007). The effect of genetic diversity on testicular morphology in free-ranging lions has also been published (Munson *et al.* 1996).

Because of the lack of lion reproductive anatomical literature, the literature was searched for applicable anatomical studies of other species. Only an ultrasonographic study by the authors on the ultrasonographic and laparoscopic characteristics of the reproductive tract of the lion exists (Kirberger *et al.* 2011). The ultrasonographic anatomy of the liver, spleen and urinary tract of the cheetah (*Acinonyx jubatus*) has been described (Carstens *et al.* 2006).

An excellent textbook published in 1969 covers the various components of the urinary tract (Crouch 1969d) and reproductive tract of the domestic cat (Crouch 1969c). The latter consists of the ovaries, uterine tubes, uterus, vagina, vestibule (uroreproductive sinus) and vulva (Crouch 1969a). Crouch reported on the size and location of the ovaries, the mesovarium, oviduct, mesosalpinx, proper ligament of the ovary, mesometrium, round ligament, suspensory ligament and right and left horns. Crouch also described the topography of the uterus, cervix, vagina, vestibule, urethral tubercle, vestibular glands, clitoris and its fossa, vulva and labia together with the relevant arteries and veins. The gravid uterus, its placenta and blood supply have also been described (Crouch 1969b). In another feline anatomy textbook (Nickel *et al.* 1979), reference is made to several unobtainable older publications including a dissertation in 1911 by De Bryun-de Ouboter on the juvenile and gravid uterus of the domestic cat, a description of the reproductive organs of the cat in 1933 by Seiferle and a dissertation in 1935 by St Bede on the reproductive organs of the domestic cat.

The reproductive anatomy of the bitch and location of ovaries in relation to the kidneys (Evans 1993b) are well described, and the anatomy and histology of the uterotubal junction of various mammalian species have been investigated and compared (Hook and Hafez 1956).

Various terms for anatomical structures are available both in Latin and English. Some authors use Latin terminology and other prefer English depending on the audience involved. For the purposes of this article, English terminology will be used unless only the Latin version exists. For instance, the uterine tube has synonyms, like Fallopian tube, oviduct, *tuba uterina* and s*alpinx,* which have been used by various authors in the past (Crouch 1969a,c; Nickel *et al.* 1979; International Anatomical Nomenclature Committee 1989; Evans 1993b).

Materials and Methods

Sample population

Three pubertal captive bred nulliparous lionesses aged approximately 3 years were obtained from a farm in South Africa. The lionesses were lured with bait and distress calls and subsequently darted with a combination of zolazepam and tiletamine (Zoletil®; Virbac, Halfway House, South Africa) at a dose of 3.3 mg/kg administered intramuscularly. The common carotid artery was catheterised with a feeding tube, and lions were bled out into a trough until cardiac arrest occurred. Further suction was applied to the intra-arterial catheter to evacuate as much arterial blood as practically possible, and a 4% formalin solution was run in by gravity. Cotton wool plugs were placed in the nostrils, pharynx, rectum and vagina to prevent seepage from the orifices. Approximately 17 L of formalin was needed to embalm each lioness. The cadavers were transported to the Department of Anatomy and Physiology, Faculty of Veterinary Science, Onderstepoort, South Africa, and stored in formalin baths.

The lionesses were rinsed in a water bath for 24 h prior to the study and each lioness numbered from one to three, using yellow Aussie ear tags (Milborrow). After weighing the formalin-prepared cadavers on an electronic scale, 17 kg was subtracted for formalin present in the carcass, 7 kg added to compensate for blood loss during exsanguination and 1 kg was subtracted for metal suspension hooks present on the cadaver. Body weights were 120.5, 138.5 and 140.5 kg.

Two fresh carcasses from another study were used for some of the topographical photographs because these rendered better quality images. The project was approved by the University's Animal Use and Care Committee and Research Committee (protocol number V038-09).

Procedures

The cadavers were suspended in a natural position by two hooks and the skin over the abdominal walls was bilaterally reflected ventrally. A sagittal incision was made on the dorsal midline from the twelfth thoracic vertebra (T12) to the level of the iliac crest and two dorsoventral incisions from T12 and the level of the iliac crest down to the ventral midline. The external abdominal oblique muscles were bilaterally reflected ventrally to the *linea alba*. A longitudinal incision was made into the superficial lumbar fascia at the level of the border between the epaxial and abdominal muscles extending from the coxal tuberosity to the twelfth rib. This was followed by two dorsoventral incisions at the level of T12 and the coxal tuberosity down to the ventral midline. The internal abdominal oblique muscles were bilaterally reflected ventrally to the lateral edge of the rectus abdominous muscles by means of a longitudinal incision into the deep lumbar fascia at the level of the border between the epaxial and abdominal muscles from the coxal tuberosity to the costal tuberosity of the thirteenth rib (R13). This was followed by two dorsoventral incisions along the costal arch and from the coxal tuberosity down to the ventral midline. The transverse abdominal muscles were bilaterally reflected dorsally by means of a longitudinal incision at the level of the lateral edge of the rectus abdominous muscles followed by dorsoventral incisions along the costal arch and the ventral midline to the coxal tuberosity. Anatomical evaluation of the organs was made and they were photographed. The topography of the kidneys, suspensory ligaments and ovaries was studied and described and topographic data recorded. Although the kidneys do not form part of the female reproductive organs, their topography was investigated because ovarian topography is dependant on them. All measurements were taken in centimetres. The kidney measurements were taken from the tuberculum and caudal arch of the R13 and from the iliac crest to the centre of the kidneys. Ovarian measurements were taken from the caudal pole of the kidney to the cranial pole of the ovary and from the centre of the ovary to the iliac crest. The sagittal location of the ovaries in relation to the kidneys was described. The cadaver was then split into cranial and caudal halves. The bilateral caudal dorsoventral incisions at the level of the coxal tuberosity were connected ventrally; the distal descending colon was double ligated and transected; the mesocolon, mesoduodenum and duodenocolic ligament were horizontally severed; the spine was split at the cranial aspect of the first lumbar vertebra (L1); the caudal lumbo-diaphragmatic recess was entered and the crura of the diaphragm were transected at the level of L1; the caudal vena cava and aorta were transected; and the caudal half of the cadaver was separated with only the urogenital tract and rectum attached to it. The rest of the abdominal viscera were left attached to the cranial half of the cadaver.

The various structures were photographed, and topographical data were described with the organs still *in situ*. The abdominal aorta was dissected to reveal all its branches as well as the bifurcation, and the relationship of the reproductive organs relative to the phrenico-abdominal and deep circumflex arteries was investigated. The position of cranial pole of both ovaries, tip of both uterine horns and the origin of both ovarian arteries were measured from the centre of the ipsilateral phrenico-abdominal and deep circumflex iliac arteries. For the purposes of future laparoscopic surgery, the distance from the parietal peritoneum (abdominal wall) to the centre of the respective ovaries was measured. The maximum distance was measured from the reflexion of the medial aspect of the mesovarium onto the parietal peritoneum up to the mesovarial margin at the centre of the ovary.

The pelvis was then sagittally split with all of the intrapelvic organs positioned in the right hemipelvis. Redundant left-sided intrapelvic muscles and soft tissue were resected. The lines of peritoneal reflection were studied to describe the peritoneal excavations and recorded. The following structures were described in relation to the cranial border of the pubis: the pubovesical pouch situated ventrally between the bladder with its lateral ligaments and the pubis, the vesicogenital pouch situated between the genital fold with uterine broad ligament and the bladder with its lateral ligaments, the rectogenital pouch situated dorsally between the roof of the pelvis and the uterine broad ligament and the pararectal fossae extending bilaterally on either side of the rectum.

The reproductive tract including bilateral mesovaria, mesosalpinges, mesometria (including the intrapelvic part), suspensory ligaments (including the cranial part of the mesovarium), ovaries, proper ligament, tubular structures as well as the uterus, vagina, vulva and bladder were then removed. The specimens were rinsed in clear water for 24 h and subsequently studied by two observers (MH and HG). Photography of all the above-mentioned structures on the individual specimens was taken on a blue-coloured background. The diameter of the cervix and the dimensions of the uterine tubes were taken before the organs were incised. The tubular parts were then incised longitudinally along their respective lumina. The lining and inner structure of the uterus, vagina, vulva and vaginal vestibule was macroscopically examined and measured using a Vernier calliper. The length of the vaginal vestibule was measured from the cranial border of the urethral tubercle to the mucocutaneous junction of the vulva. The length of vagina was measured from the cranial border of the urethral tubercle to the external orifice of the cervix. The length of the cervix was measured from the cranial extent of the vaginal fornix to the external orifice of the cervix. The length of uterine body was measured from the internal orifice of the cervix to the point of convergence of the two uterine horns. The length of the uterine horns was measured from the convergence of the two uterine horns to their respective tips. The width of the ovaries was measured from the free margin to the mesovarial margin at the widest point and the length from the tubular pole to the uterine pole. Both left and right ovaries were separated from the rest of the reproductive organs, weighed and macroscopically examined. The ratio of ovarian weight to body weight was calculated.

A total of three animals is a limitation to this study; however, large numbers of exotic animals are not commonly available for cadaveric studies and the ethical issue of euthanizing more individuals has to be considered.

Results

Kidneys

Each kidney was located lateral to the abdominal aorta and the caudal vena cava. The left kidney was located further caudally than the right (Fig. 1). The centre of the left kidney ranged from 15.4 to 16.8 cm caudal to the costal tuberculum of

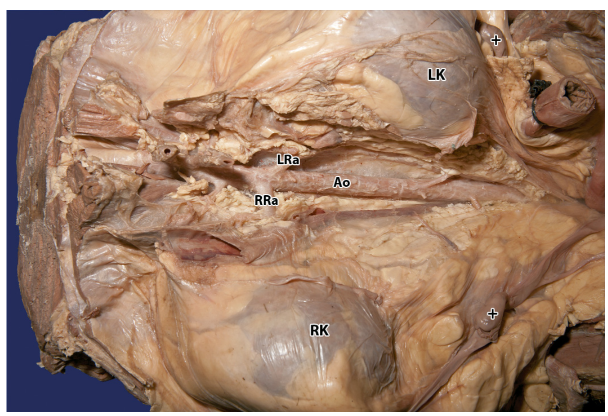

Fig. 1—Kidney location. Left kidney (LK). Right kidney (RK). Ovaries (+). Aorta (Ao). Left renal artery (LRa). Right renal artery (RRa). Cranial is to the left of this picture and caudal to the right. This orientation applies to all figures.

Table 1 Topographical location of kidneys in three lionesses

	Costal tubercle of rib 13 to centre of kidney (cm)		Caudal costal arch of rib 13 to centre of kidney (cm)		Centre of kidney to iliac crest (cm)	
Lioness	Left	Right	Left	Right	Left	Right
1	16.8	12.5	7.5	3.3	12	12.6
2	16.4	13.2	7.6	3.6	11.2	14.1
3	15.4	10	7.4	3.1	12.2	16.2
Mean	16.2	11.9	7.5	3.3	11.8	14.3

the left R13 and the right kidney from 10.0 to 13.2 cm caudal to the costal tuberculum of the associated R13 (Table 1). The centre of the left kidney ranged from 7.4 to 7.6 cm caudal to the most caudal aspect of the costal arch of the R13 and that of the right kidney from 3.1 to 3.6 cm caudal to that of the R13 (Table 1). The left kidney was therefore situated caudal to the costal tuberosity of the R13, 60% of the distance from the tuberosity to the iliac crest. The location of the right kidney was 45% caudal to the costal tuberosity of the R13 in relation to the iliac crest. The cranial pole of the right kidney was embedded in a well-developed renal fossa in the caudate process of the caudate liver lobe. A remarkable volume of retroperitoneal perirenal fat was present at the cranial pole of the right kidney, which fitted snugly into the renal fossa.

Ligaments

The suspensory ligament originated in a fan-like manner with several thick separate bands from the dorsolateral abdominal wall lateral to the kidney extending up to a few centimetres cranial to the kidney (Fig. 2). The proper ligament was thick with several bands of tissue extending from the caudal pole of the ovary onto the uterine horn (Fig. 3). The broad ligament consisted of a cranial part of the mesovarium, the mesovarium, the mesosalpinx and the mesometrium. The cranial part of the mesovarium containing the suspensory ligament was well developed (Fig. 4). The round ligament was well developed (Fig. 5) having a pronounced thickening in the edge of a free peritoneal fold derived from the lateral peritoneal layer of the broad ligament. The ligament originated from the uterine horn, 2–3 cm caudal to the tip of the horn and inserted on the medial femoral fascia. The intercornual ligament was visible but poorly developed (Fig. 5).

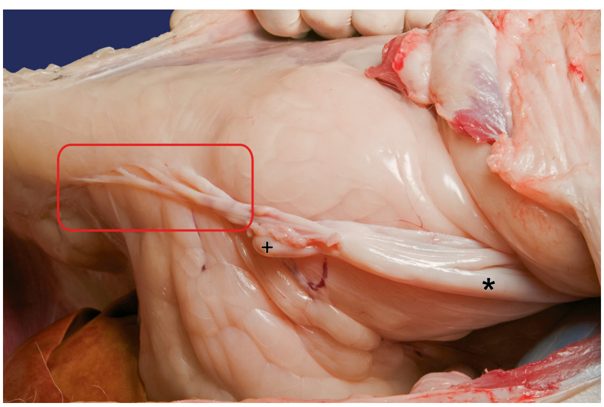

Fig. 2—Suspensory ligament (rectangle). Ovary (+). Uterine horn (*).

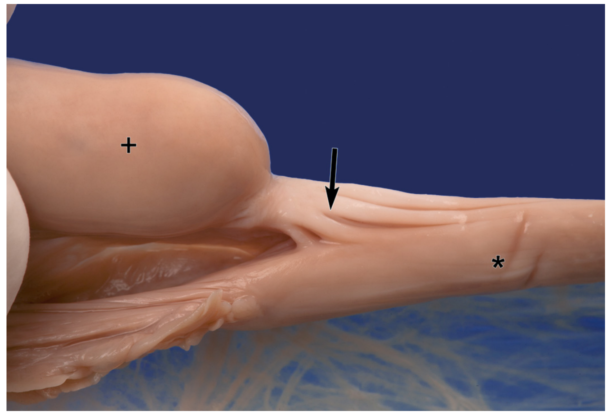

Fig. 3—Proper ligament (arrow). Ovary (+). Uterine horn (*).

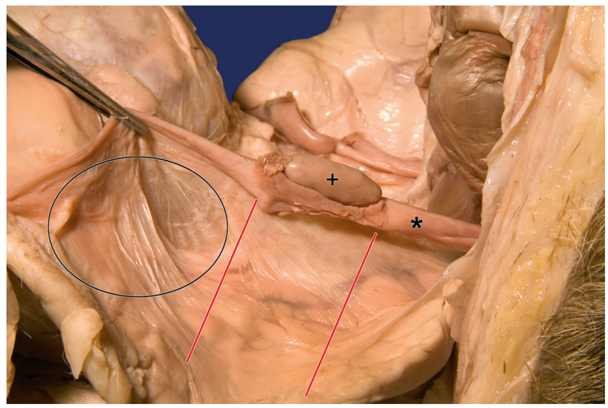

Fig. 4—Mesovarium (parallel lines). Cranial part of the mesovarium (oval). Ovary (+). Uterine horn (*).

Ovaries

The left ovary was consistently located adjacent to the caudolateral aspect of the caudal pole of the ipsilateral kidney. The position of the cranial pole of the right ovary ranged from 3.8 to 3.9 cm caudal to the caudal pole of the right kidney (Table 2) in the direct sagittal midline of the respective kidney (Fig. 1).

The phrenico-abdominal arteries were embedded in soft tissue and required significant dissection to reveal their origin. The deep circumflex arteries were always visible and required

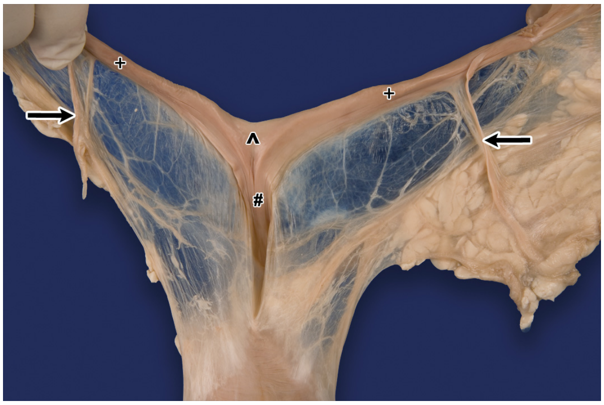

Fig. 5—Round ligaments (arrows). Intercornual ligament (^). Uterine horns (+). Uterine body (#).

much less dissection to reveal their origin. The two phrenico-abdominal and two deep circumflex iliac arteries originated from the abdominal aorta and lay opposite one another. The left and right ovaries were located between 12.1 and 17.1 cm and between 14.5 and 15.2 cm caudal to their respective ipsilateral phrenico-abdominal artery (Table 3). The location of the left ovary in relation to the deep circumflex iliac artery was variable and ranged from 5.9 to 8.7 cm cranial to the ipsilateral artery (Table 4). The position of the right ovary was constantly situated 8 cm cranial to the ipsilateral deep circumflex artery (Table 4).

The left ovary weighed between 1.4 and 2.5 g, with a length of between 2.7 and 3.2 cm and width of between 1.1 and 1.4 cm. The right ovary weighed between 1.1 and 2.2 g, with a length of between 2.7 and 3.0 cm and width of between 0.9 and 1.2 cm (Table 5). The ratio of ovarian weight to bodyweight varied between 0.00001 and 0.000017 (Table 5). The origin of the left ovarian artery was located between 10.0 and 11.8 cm caudal to the origin of the ipsilateral phrenico-abdominal artery and between 3.9 and 5.6 cm cranial to that of the deep circumflex iliac artery. Likewise, the origin of the right ovarian artery was located between 9.8 and 12.3 cm caudal to the origin of the phrenico-abdominal artery and between 2.7 and 3.9 cm cranial to that of the deep circumflex iliac artery (Tables 3 and 4).

Table 3 Topographical location of anatomical landmarks of female reproductive organs situated caudal in relation to the origin of the ipsilateral phrenico-abdominal arteries

Lioness	LO (cm)	RO (cm)	TLUH (cm)	TRUH (cm)	OLAO (cm)	ORAO (cm)
1	12.1	14.5	13.8	16.1	10	11.4
2	16.4	15.2	17.8	16.9	11.8	12.3
3	17.1	14.5	17.9	16.3	10	9.8
Mean	15.2	14.7	16.5	16.4	10.6	11.2

LO – cranial pole of left ovary; RO – cranial pole of right ovary; TLUH – tip of left uterine horn; TRUH – tip of right uterine horn; OLAO – origin of left ovarian artery; ORAO – origin of right ovarian artery.

The ovarian bursa had a short mesosalpinx that did not cover any part of the ovary (Fig. 6) and extended the entire length of the ovary. The mesosalpinx however was thick and tough (Fig. 7) and contained the convoluted uterine tube. The distance from the parietal peritoneum to the centre of the left ovary was highly variable, between 1.9 and 3.6 cm. However, this distance for the right ovary was relatively constant between 2.8 and 3.0 cm (Table 4).

Structures found on the ovaries included various immature follicles as well as one superficial cyst-like structure and a peri-ovarian cyst.

Peritoneal excavations

The pubovesical and vesicogenital pouches were situated cranial to the cranial border of the pubis in two lions with the vesicogenital pouch further cranial. The rectogenital pouch and pararectal fossae were located intrapelvically with the latter further caudal. The vesicogenital pouch extended to the level of the cervix and the rectogenital pouch to the caudal

Table 2 Topographical location of ovaries

Lioness	Distance between caudal pole of kidney and cranial pole of ovary (cm)		Medio-lateral topographic location of ovary		Distance from centre of ovary to iliac crest (cm)	
	Left	Right	Left	Right	Left	Right
1	0	3.8	Immediately caudolateral to caudal pole	Caudally in the sagittal midline of the kidney	6.8	7.1
2	0	3.9	Immediately caudolateral to caudal pole	Caudally in the sagittal midline of the kidney	7.3	7.1
3	0	3.9	Immediately caudolateral to caudal pole	Caudally in the sagittal midline of the kidney	6.1	7.2
Mean	0.0	3.9	–	–	6.7	7.1

Table 4 Topographical location of anatomical landmarks of female reproductive organs situated cranial in relation to the origin of the ipsilateral deep circumflex iliac arteries

Lioness	LO (cm)	RO (cm)	TLUH (cm)	TRUH (cm)	OLAO (cm)	ORAO (cm)	PPLO (cm)	PPRO (cm)
1	5.9	8.1	4.1	6.8	5.6	3.9	3.6	2.9
2	8.2	8	5.6	6.2	4.2	3.2	1.9	2.8
3	8.7	7.8	7.5	7.3	3.9	2.7	2.8	3
Mean	7.6	8.0	5.7	6.8	4.6	3.3	2.8	2.9

LO – cranial pole of left ovary; RO – cranial pole of right ovary; TLUH – tip of left uterine horn; TRUH – tip of right uterine horn; OLAO – origin of left ovarian artery; OAO – origin of right ovarian artery; PPLO – distance from parietal peritoneum to centre of left ovary; PPRO – distance from parietal peritoneum to centre of right ovary.

Table 5 Splanchnological data of the ovaries

Lioness	Body mass (kg)	Left ovary			Right ovary			Ratio O/B
		Weight (g)	Length (cm)	Width (cm)	Weight (g)	Length (cm)	Width (cm)	
1	120.5	1.4	2.7	1.2	1.1	2.7	0.9	0.000010
2	138.5	2.5	3.2	1.4	2.2	3	1.2	0.000017
3	140.5	2.3	2.9	1.1	1.8	3	0.9	0.000015
Mean	133.2	2.1	2.9	1.2	1.7	2.9	1.0	0.000014

Ratio O/B – ratio of mean ovarian weight over bodyweight.

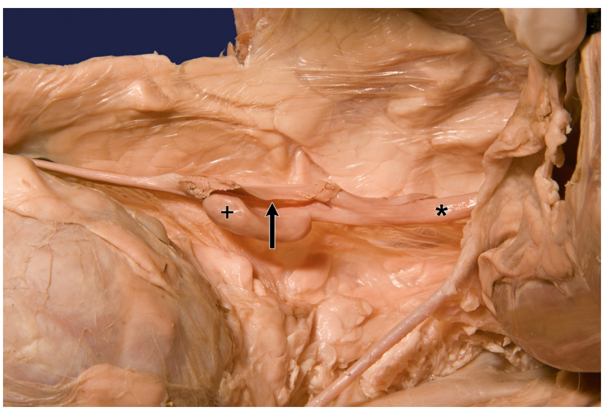

Fig. 6—Ovarian bursa (arrow). Ovary (+). Uterine horn (*).

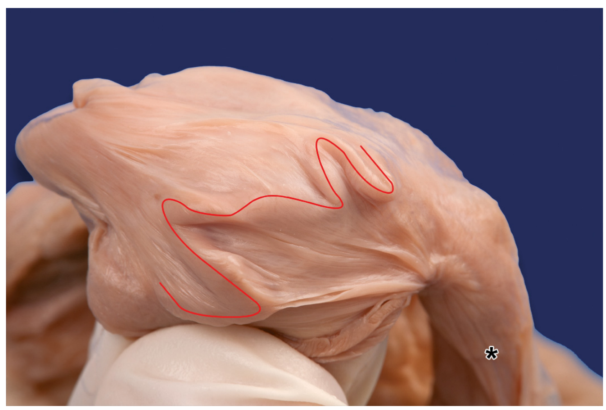

Fig. 7—Ovarian bursa viewed from the lateral surface. Thick mesosalpinx and convolution of the uterine tube (irregular line). Uterine horn (*).

margin of the vagina. The peritoneal excavations in general were found to be highly variable amongst individuals (Table 6).

Tubular parts

The vaginal vestibule was between 6.4 and 6.8 cm long and the vagina between 8.2 and 10.4 cm (Table 7). The longitudinal folds of the vaginal vestibule were fewer but much more prominent (higher and wider) than those of the vagina (Figs 8 and 9). A large external urethral orifice was situated on a well-developed urethral tubercle. A well-developed urethral crest extended from the tubercle caudally into the vaginal vestibule ventrally (Fig. 8). The clitoris and its fossa were poorly developed (Fig. 8). The cervix was between 1.4 and 2.1 cm long, between 1.3 and 1.6 cm in diameter (Table 7) and was constantly located intrapelvic. It was thick walled with fine longitudinal folds and was notably short and small in relation to the rest of the reproductive organs (Fig. 10). The vaginal fornix was prominent (long) in relation to the cervix. The

Table 6 Topographical location of lines of peritoneal reflection in relation to the cranial border of the pubis

Lioness	Pubovesical pouch (cm)	Vesicogenital pouch (cm)	Rectogenital pouch (cm)	Pararectal fossa (cm)
1	−1.8	−3.7	6.1	10.3
2	1.8	0.7	6.9	7.4
3	−0.5	−1.5	7.1	8.6
Mean	−0.2	−1.5	6.7	8.8

Negative figures indicate a location cranial to the cranial border of the pubis.

uterine body was between 2.5 and 3.2 cm in length (Table 7) and contained fewer (in number) longitudinal folds than the uterine horns. Also, the longitudinal folds of the uterine horns were better developed than those of the body. The left uterine horn was between 12 and 21.1 cm in length and the right uterine horn between 11.7 and 14.8 cm (Table 7). With respect to the phrenico-abdominal artery, the tip of the left uterine horn was located between 13.8 and 17.9 cm caudal to the artery (Table 3) and between 4.1 and 7.5 cm cranial to the ipsilateral deep circumflex iliac artery (Table 4). The tip of the right uterine horn was located between 16.1 and 16.9 cm caudal to the ipsilateral phrenico-abdominal artery and between 6.3 and 7.3 cm cranial to the respective deep circumflex iliac artery. The tip of the uterine horn was located dorsal to the well-developed proper ligament (Fig. 6). The uterine tube had well-developed fimbriae that extended along the lateral aspect of the ovary for its entire length. The infundibulum started approximately in the mid ovary from where the uterine tube ran cranially then turned dorsally at the cranial pole and then caudally towards the tip of the uterine horn (Fig. 7) where it opened directly into the tip of the uterine horn (Fig. 11). The uterine tube was prominently convoluted.

Discussion

Kidneys

Each kidney was located lateral to the abdominal aorta and the caudal vena cava with the right kidney cranial to the left as in the cat (Crouch 1969d; Nickel *et al.* 1979) and the dog (Evans 1993b). The kidneys appeared big in relation to the rest of the cadaver, and both kidneys were located far caudally in relation to the last rib. There was some variation in the location of the right kidney. The location of the kidneys with respect to the last rib has not been described in the cat. In the dog, the cranial pole of the left kidney lies about 5 cm caudal to the upper third of the last rib and the cranial pole of the right kidney lies at the level of the R13 (Evans 1993b). The cranial pole of the right kidney was embedded in the renal fossa of the caudate liver lobe with the prominent interposed perirenal fat. This is similar to the ultrasonographic findings in the cheetah where there is a 38 mm space between the cranial pole of the right kidney and the renal fossa (Carstens *et al.* 2006). No floating left kidneys were found as can be seen in the cat (Nickel *et al.* 1979).

Ligaments

The suspensory ligament was particularly well developed and had a unique structure and appearance. It did not originate from the middle of the last one or two ribs like in the cat (Crouch 1969c) and dog (Evans 1993b) but in a fan-like manner with various thick separate bands from the dorsal and dorsolateral abdominal wall cranial and lateral to the kidney. In a separate study on two fresh carcasses immediately post-mortem, it was noticed that the suspensory ligament had the ability to significantly contract and relax. In the authors' opinion, the proper ligament was particularly well developed compared to that of the dog and cat. The characteristics of the suspensory ligament and proper ligament might enable the lioness, who is the primary hunter (Skinner and Chimimba 2005), to suspend her ovaries and uterus closer to the body wall for hunting purposes, especially during pregnancy. This could possibly prevent excessive intra-abdominal motion of the uterus and its contents as the lioness has to sustain high speeds for prolonged periods during hunting compared to other big cat predators. She also has to jump on top of large prey during the kill. A recent study determined the lioness's

Table 7 Splanchnological data of tubular parts

Lion	A (cm)	B (cm)	C (cm)	D (cm)	E* (cm)	F (cm)	G (cm)	H (cm)	I* (cm)	J* (cm)	K* (cm)	L* (cm)
1	6.7	9.5	16.2	1.5	1.5	3.2	21.1	11.7	2.9	2.3	0.3	1.2
2	6.4	8.2	14.6	2.1	1.6	2.5	14.1	14.8	c	3.5	0.3	1.3
3	6.8	10.4	17.2	1.4	1.3	3	12	12.2	c	c	0.3	1.2
Mn	6.6	9.4	16.0	1.7	1.5	2.9	15.7	12.9	2.9	2.9	0.3	1.2

A – length of vaginal vestibule (measured from the cranial border of the urethral tubercle to the mucocutaneous junction of the vulva); B – length of vagina (measured from the cranial border of the urethral tubercle to the external orifice of the cervix); C – length of vaginal vestibule + length of vagina; D – length of cervix; E – transverse diameter of cervix; F – length of uterine body (measured from the internal orifice of the cervix to the point of convergence of the two uterine horns); G – length of the left uterine horn; H – length of the right uterine horn; I – length of the left uterine tube; J – length of the right uterine tube; K – diameter of the left uterine tube; L – diameter of the right uterine tube; c – convoluted; Mn – Mean; SD – standard deviation. *Measurements taken before incising and opening of tubular parts.

Fig. 8—Clitoris. Opening to the clitoral fossa (oval). The clitoral fossa was incised and exposed (arrow).

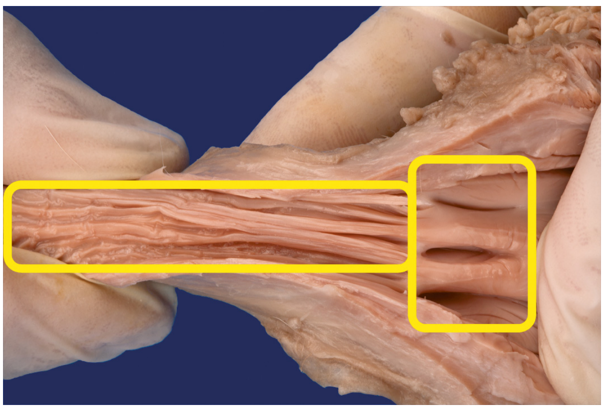

Fig. 9—Vestibulum containing the urethral tubercle (short and wide rectangle). Vagina (long and narrow rectangle).

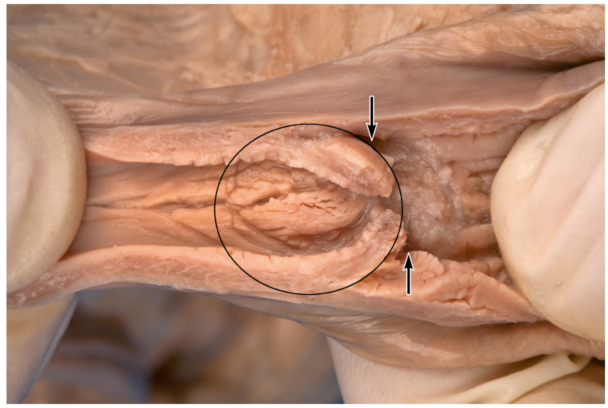

Fig. 10—Cervix (circle) and vaginal fornix (arrows).

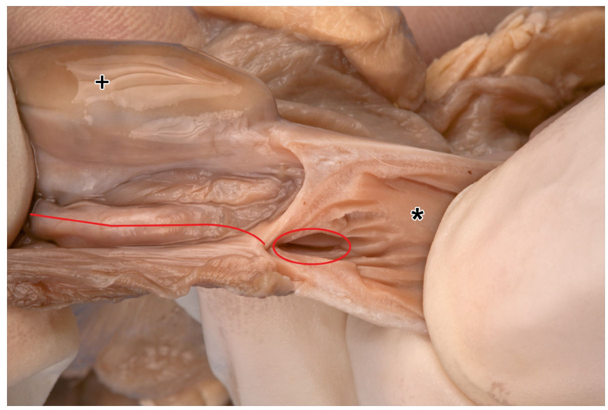

Fig. 11—Ovary and its bursa viewed from the medial surface. Ovary (+). Uterine tube (curved line) and its opening (oval) seen in the exposed lumen of the uterine horn. Uterine horn (*).

muscle fibre to be type IIx (Kohn *et al.* 2011), which corroborates the above statements. The broad ligament was similar to that of the cat and dog but with a much better developed cranial part of the mesovarium. The round ligament was well developed (Fig. 5) similar to that of the cat (Crouch 1969c) and dog (Evans 1993b). It extended through the inguinal canal but did not terminate subcutaneously in or near the vulva as in these two species. The unique characteristics and origin of the suspensory ligament, the location of the tip of the uterine horn dorsal to the proper ligament, the well developed proper and round ligaments and insertion of the round ligament on the medial femoral fascia might play a role in the behaviour of the lioness when she rolls over on her back and extends her pelvic limbs after mating. This behaviour in conjunction with the above-mentioned characteristics might facilitate the ability of sperm to enter the uterine tube more effectively. The intercornual ligament was poorly developed when compared to that of the dog.

Ovaries

The position of the right ovary was relatively more constant and that of the left ovary more variable (Table 3). The left ovaries were generally heavier and bigger than the right, which could account for their more variable location (Table 6). The ovary-to-body weight ratio of the dog was calculated by the authors from existing data to be 0.000025 (Evans 1993b). The ovaries of the lioness were half the size compared to that of a sexually mature 25 pound dog (Table 5). The ovarian bursa was poorly developed compared to that of the dog with most of the ovary readily visible (Evans 1993b). This will result in visualisation of the ovary and associated uterine tube during laparoscopy enabling laparoscopic salpingectomy, which the senior author has already managed to perform successfully in a separate study. This is contrary to the dog where this laparoscopic procedure cannot be performed because the ovarian bursa covers the entire ovary resulting in the uterine tube being poorly visible. In the domestic cat, this procedure should also be possible. Despite the distance from the parietal peritoneum to the centre of the left ovary being highly variable and that of the right ovary being relatively constant, it was evident that sufficient displacement of the ovaries from the abdominal wall would be achievable during laparoscopic surgery.

Peritoneal excavations

The peritoneal excavations were found to be highly variable. However, in general, the location of the pubovesical and vesicogenital pouches was intra-abdominal and that of the rectogenital pouch and pararectal fossae were intrapelvic. This compared to the bitch where the pubovesical pouch is located within the first 2 cm after entering the pelvic cavity and all of the peritoneal excavations are situated intrapelvic (Evans 1993a). Because of the intrapelvic location of the rectogenital pouch, it will be difficult in the lioness to visualise and reach this area during laparoscopic surgery but insufflation of the peritoneal cavity may assist. The vesicogenital pouch was situated intra-abdominally and would therefore be easier to access. Laparoscopic access to the dorsal aspect of the reproductive tract will extend further caudal than that of the ventral aspect with the entire vagina accessible dorsally but only the cervix ventrally.

Tubular parts

The tubular parts contained a variety of longitudinal folds of varying degree depending on the specific area. The external urethral orifice, urethral tubercle and urethral crest were regarded as relatively well developed when compared to that of the cat (Crouch 1969a) and dog (Evans 1993b). These aspects in combination with the very prominent longitudinal folds of the vaginal vestibule could possibly hamper urethral catheterisation, which was encountered during a separate study on two young anaesthetised lionesses when the senior author and co-workers failed to pass a urethral catheter. The clitoris and clitoral fossa were small and poorly developed (Fig. 7), which correlated to that of the cat (Crouch 1969a). The clitoris however did not protrude from the clitoral fossa as in the cat (Crouch 1969a). The left uterine horn was 21.7% longer than the right. Future studies are needed to determine whether the left uterine horn bears more foetuses than its right counterpart. The fimbriae were situated on the lateral aspect of the ovary and extended for its entire length. In the cat, the fimbriae are also situated on the lateral aspect of the ovary but do not extend for the entire length (Crouch 1969c). The uterine tube was situated entirely on the lateral aspect of the ovary unlike that of the cat (Crouch 1969a) and dog (Evans 1993b). The uterine tube of the cat originates laterally from the fimbriae, ascends to the cranial pole of the ovary, passes to the medial side and then runs caudally to the uterine horn (Crouch 1969c). The uterine tube did not open on a papilla as in the cat (Crouch 1969c) or dog (Hook and Hafez 1956) but directly into the tip of the uterine horn. Convolution of the uterine tube was similar to that of the cat (Crouch 1969c).

Function

The African lioness exhibits the behaviour of rolling over on her back after mating. The morphological findings including the tip of the uterine horn located dorsal to the proper ligament and the opening of the uterine tube directly into the tip of the uterine horn may facilitate migration of sperm into the uterine tube and explain this behaviour. The fact that the round ligament inserts on the medial femoral fascia combined with the well developed proper and suspensory ligaments might assist the pregnant lioness, who is the primary hunter in the pride, to suspend a gravid uterus closer to her body wall while hunting large prey species.

Application

We found that this study provided a detailed description of the morphology of the female reproductive organs, which was subsequently used by the primary author in performing laparoscopic ovariectomy and salpingectomy of the African lioness. Because there is a great need for effective population control of lions in South Africa without disrupting the social pride structure, the splanchnological characteristics of the salpinx and ovarian bursa lead to the concept of salpingectomy in this species and may greatly assist in providing solutions to this need. An additional study on the histology of the ovaries and tubular parts is currently underway. During this study, particular attention will be paid to determine whether the suspensory, proper and round ligaments consist of smooth muscle, as in the cat (Crouch 1969c).

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