

Vaginal and cervical modifications during the estrus cycle in the domestic cat

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Abstract

A thorough knowledge of the genital tract anatomy and vaginal and cervical modifications during the phases of estrus cycle of the female cat is necessary to enhance success of assisted feline reproductive technologies or for other diagnostic or therapeutic purposes. There are few studies of the gross anatomy of the genital tract in the queen. The vestibule is large in comparison to the vagina; the latter has a narrow lumen, which is further constricted by the prominent dorsal median fold. The cervix is oriented obliquely between the uterine body and vagina. Vaginal and cervical changes in association with the estrous cycle have been reported in some species and two recent studies investigated this aspect in the cat. This paper reviews the relevant literature, with particular emphasis on recent studies.

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1. Introduction

New technologies for assisted reproduction in the cat are emerging, but some procedures, such as transcervical catheterization (for AI, embryo collection or diagnostic or therapeutic purposes) are not well documented. The first studies reporting pregnancy after AI in the cat [1,2] were vague with respect to site of semen deposition. One report in 1993 [3] confirmed the presence of a urogenital sinus in the queen that leads to a narrow vagina and the cervix, which is located approximately 45 mm from the vulva and forms an obtuse angle with the vagina. Another study [4] reported the development of a catheter for

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transcervical embryo transfer. A report in 2004 [5] provided the first study of vaginal and cervical modifications during the various stages of the estrous cycle. The length of the fornix increased, height of the vagina at the level of the cervix decreased, and the width of the angle between cervical and vaginal axes decreased during the follicular phase. These changes, related to an increase of the dorsal medial fold, could explain the low success rate of transcervical catheterization during this period. The objective of this paper is to review the literature related to cyclic genital tract changes and to offer suggestions to improve assisted reproductive techniques in the cat.

2. Anatomy

Although AI was first reported in the cat during the 1970s [1,2], the genital anatomy of queen was not well described. Limited studies to define the reproductive anatomy of the queen were incomplete and reported discordant opinions. The presence of the urogenital sinus in the queen was confirmed in 1993 [3]. This structure was characterized as 1–2 cm long, leading to a narrow and non-distensible vagina. The urogenital sinus permitted passage of a 4 mm probe, while the vagina only allowed passage of a 1 mm probe. Stimulation of the anterior limit of the urogenital sinus induced vocalization, similar to that during coitus [3]. The cervix was located 40–45 mm anterior to the vulva and formed an obtuse angle with the vagina [3]. The vaginal fornix was located ventrolateral to the cervix. Swanson and Godke [4] confirmed the presence of the previously reported [6] prominent dorsal medial postcervical fold. The anatomy of the caudal reproductive tract of the queen is shown in Fig. 1.

3. Vaginal and cervical anatomic modifications during the estrous cycle

Watson and Glover [3] used estrus and interestrus queens to study vaginal anatomy in relation to copulation and artificial insemination. Swanson and Godke [4] reported genital

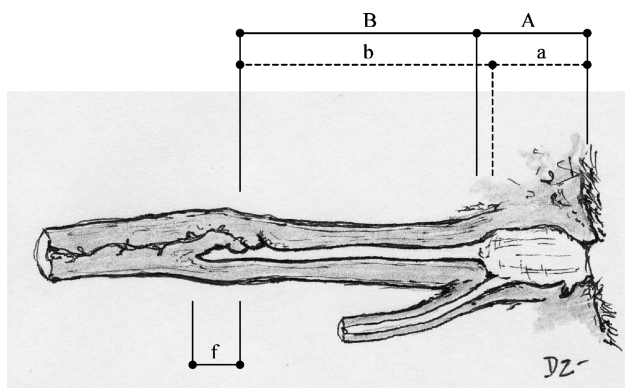


Fig. 1. Longitudinal section of the low reproductive tract in the queen. Horizontal dashed line: measures taken by Watson and Glover [3]: urogenital sinus (A), vagina (B). Horizontal continuous line: measures taken by Swanson and Godke [4]: vestibule (a), vagina (b). Fornix (f).

Table 1

Mean ($\pm$ S.D.) depth of insertion of probes placed in the vagina during various stages of the estrous cycle in the queen

Stage of estrus cycle	Probe diameter (mm)	Depth of insertion (mm)
Anestrus	1	55.9 $\pm$ 8.2
	1.3	55.6 $\pm$ 8.2
	2	40.4 $\pm$ 13.3
Diestrus	1	54.2 $\pm$ 6.4
	1.3	52.2 $\pm$ 7.5
	2	38.7 $\pm$ 13.3
Interestrus	1	51.4 $\pm$ 3.8
	1.3	47.8 $\pm$ 4.6
	2	36.9 $\pm$ 12.4
Estrus	1	52.3 $\pm$ 9.6
	1.3	48.2 $\pm$ 9.8
	2	41.2 $\pm$ 10.9

characteristics of the queen, but without regard to phase of the estrous cycle. Unlike larger animals that may be examined with a vaginoscope, the narrow lumen of the cat precludes visualization of the cervix and vagina with a standard endoscope. Zambelli and Castagnetti [7] evaluated vaginal depth using three different flexible probes (1, 1.3 and 2 mm in diameter, respectively).

In all stages of the estrous cycle, there were differences ($P < 0.05$) between depth of insertion of the 1.3 mm versus 2 mm probe, and the 1 mm versus 2 mm probe. Similarly, there was a significant difference between the depth of insertion of the 1 mm and the 1.3 mm probes ($P < 0.05$), but only in estrus and interestrus queens. The depth of insertion of the 1.3 mm probe differed ($P < 0.05$) between anestrus and estrus queens, and between anestrus

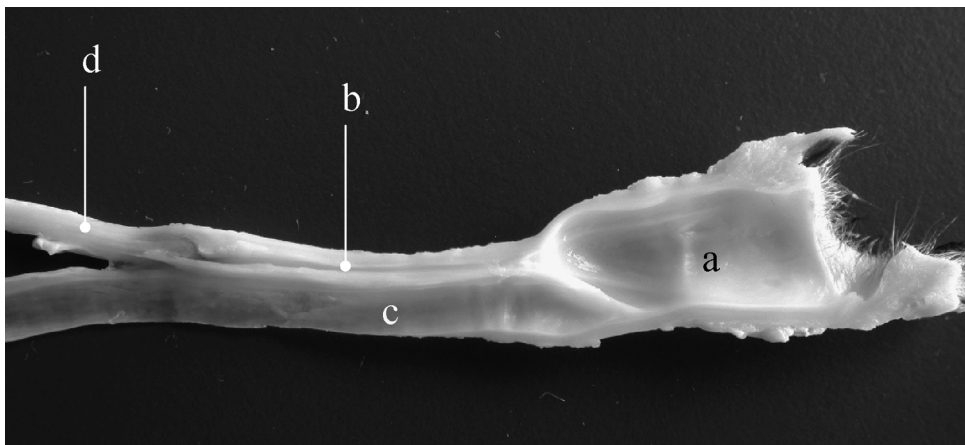


Fig. 2. Longitudinal section of a formalin-preserved caudal genital tract of the queen. Vestibule (a), vagina (b), urethra (c), uterine body (d).

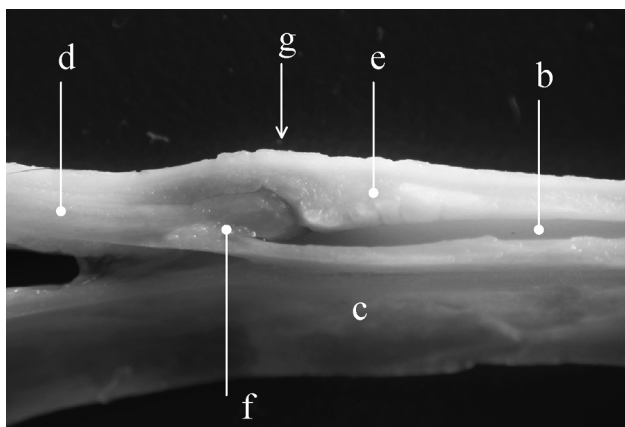


Fig. 3. Longitudinal section of a formalin-preserved caudal genital tract (particularly the cervix) of the queen. Vagina (b), urethra (c), uterine body (d), fornix (f), dorsal medial fold (e), cervix (g).

and interestrus queens. In conclusion, a 2 mm probe was always blocked before reaching the fornix during all stages of estrous cycle, a 1.3 mm probe was blocked before reaching the fornix during interestrous and estrous, and only a 1 mm probe did not encounter any resistance to penetration up to the fornix throughout the estrous cycle (Table 1).

The first study investigating vaginal and cervical modifications during the stages of the estrous cycle and outside the breeding season has been reported (Figs. 2–4) [5]. Genital measurements were obtained using silicon moulds or reproductive tracts removed during follicular and luteal phases of the cycle, as well as from interestrus and anestrus queens. Total vaginal length and vaginal diameter did not differ ($P > 0.05$) during the estrous cycle (Table 2), consistent with previous research [3,7] that vaginal diameter is always <2 mm throughout the estrous cycle. However, the fornix was longer ($P < 0.05$) during the

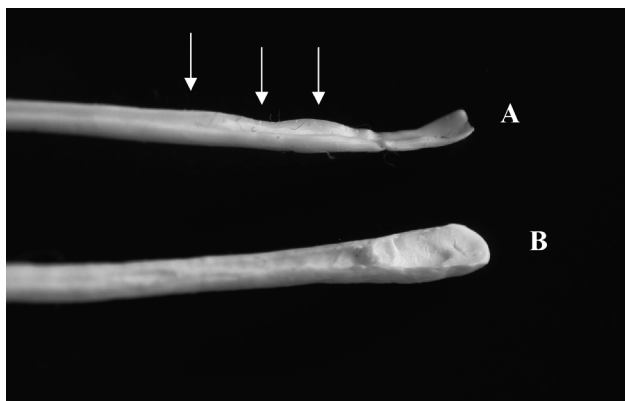


Fig. 4. Silicon moulds obtained from estrous (A) or anestrus (B) queens. The dorsal medial fold is more prominent and longer in (A) than in (B) (see the arrows); the cranial vagina lumen around the cervix is smaller in (A) than in (B) (see the thickness of the two moulds).

Table 2

Mean ($\pm$ S.D.) vaginal and cervical measurements from moulds and formalin-preserved reproductive tracts of domestic queens

Stage	Mould dimensions (mm)				
	Total vagina length	Fornix length	Vagina diameter	Angle between cervical and vaginal axis (degrees)	Vagina height
Proestrus/estrus	47.0 $\pm$ 5.5	3.3 $\pm$ 0.9 ^a	1.2 $\pm$ 0.1	137.2 $\pm$ 12.9 ^a	0.5 $\pm$ 0.1 ^a
Diestrus/pregnancy	45.8 $\pm$ 7.5	1.5 $\pm$ 0.7 ^b	1.5 $\pm$ 0.1	143 $\pm$ 6.3 ^{ab}	1.3 $\pm$ 0.2 ^b
Interestrus	47.5 $\pm$ 5.3	2.1 $\pm$ 0.9 ^{ab}	1.2 $\pm$ 0.2	131.3 $\pm$ 9.8 ^a	0.6 $\pm$ 0.2 ^a
Anestrus	49.3 $\pm$ 4.4	1.3 $\pm$ 0.9 ^b	1.6 $\pm$ 0.4	154.3 $\pm$ 8.8 ^b	1.5 $\pm$ 0.2 ^b

Values with different superscripts are different ($P < 0.05$). Data were derived from [5] © 2004 Blackwell Publishing Limited (modified).

follicular phase, compared to queens in the luteal phase or anestrus queens. Vaginal height (at the cervix) was less ($P < 0.05$) during the follicular phase and interestrus compared to luteal or anestrus queens. Width of the angle between the cervical and vaginal axes was larger ($P < 0.05$) during anestrus compared to the follicular phase and interestrus. Zambelli et al. [5] concluded that the most important modifications induced by the follicular phase were: increased length of fornix, reduced height of vagina, and decreased width of the angle between cervical and vaginal axes (Fig. 5). All of these changes could be attributed to an increase in the dorsal medial fold, confirmed by its more prominent impression on the silicon moulds obtained during the follicular phase (Fig. 4).

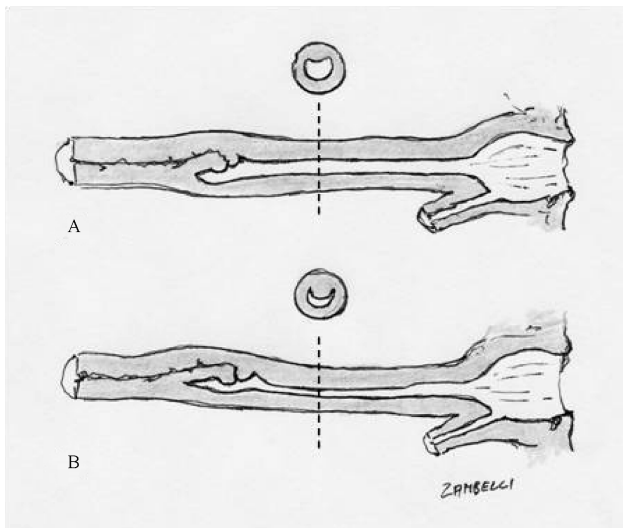


Fig. 5. Reproductive tract of two queens during different stages of the estrous cycle: anestrus (A), estrus (B). Some anatomical differences are evident: the dorsal medial fold is more prominent and longer during estrus than anestrus (see the transversal sections); the fornix is longer and flattened during estrus in comparison with anestrus; the cervical axis has a greater slope in estrus than in anestrus.

Zambelli et al. [5] also reported a higher transcervical catheterization successful rate during estrus induced during the non-reproductive season (80%), in comparison with spontaneous estrus in the reproductive season (22%). Perhaps a single estrogenic stimulation induced small cervical and vaginal modifications, whereas multiple estrogenic stimulations in a short interval (during the reproductive season) could induce more substantial changes. This hypothesis should be confirmed by comparing silicon moulds obtained from queens with induced versus spontaneous estrus. The different successful rates obtained after transcervical catheterization reported in the literature [4,5,7,8] could be attributed to different techniques as well as unreported differences in body morphology due to body weight, genetics, or breed.

4. Cervical patency during the estrous cycle

The cervix and its secretions provide important barriers between the vagina and uterus and are essential for normal sperm transport during breeding. Changes in cervical patency are well known in many species, but the cervix of the queen cannot be visualized due to the small size of the vagina. One study [9] monitored cervical patency during early, mid and late estrus and interestrus by infusing radiopaque contrast media in the vagina of queens. The cervix did not permit passage of contrast media during interestrus but was patent in relation to the degree of cornification of the vaginal cells and following peak serum concentrations of oestradiol-17- β , suggesting that intravaginal insemination might be possible from the second day of estrus (mid-estrus) through late estrus (as much as 2 days later). These findings are consistent with previous reports that the semen is deposited in the vagina of cats during coitus [3], and the cervix appears to be the major barrier to sperm deposition in the uterus, even though a small volume of radiopaque media (0.2 mL) deposited near the cervix was rapidly transported to the uterus during estrus [9].

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