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Information Bulletin

Feline Reproduction

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The cat is unique among mammals in some aspects of reproductive physiology. Understanding the cat's basic reproductive physiology and endocrinology will assist practitioners and cat breeders in assessing breeding problems that can occur with toms and queens.

The queen is seasonally polyestrous and is a reflex ovulator (ovulation and the formation of corpora lutea occur only after mating). Also, the duration of the luteal cycle of a nonpregnant queen is about one-half the duration of pregnancy; a nonpregnant queen thus returns quickly to the fertile state.

The reproductive life of the cat is long. Toms and queens can continue breeding for fourteen or more years. A queen can efficiently be continuously bred for a period of eight to ten years.

When bred continuously, most queens will have two litters of two to six kittens each a year. Siamese or Siamese crosses have slightly larger litters, averaging six kittens each. The first litters resulting from pubertal breedings are usually small, and rearing is less successful. Also, aged queens are less likely to deliver viable kittens, and usually the litter size is reduced.

Feline Puberty

Puberty in queens usually occurs between seven and twelve months of age. The timing can be influenced by the general health, breed, and weaning age of the queen and by the number of hours of artificial or natural light to which the queen is exposed. Queens can have their first estrus as early as five months of age if they have reached a minimum body weight of around five pounds, but the first estrus can occur as late as twenty-one months of age. The cat is a long-day breeder, and its estrous cycle is influenced by increasing daylight. Consequently, if the normal pubertal age and weight are reached during the anestrous (short-day) period of October to December (in the Northern Hemisphere), cycling usually begins the following January or February. If pubertal weight is attained during the period of May to September, then an earlier pubertal estrus can occur. Puberty usually occurs in toms when they have attained a minimum body weight of seven to eight pounds, at around nine months of age. If the offspring will be raised together, then the male and female kittens should be separated before they are five months old.

Purebred cats may reach puberty later than nonpurebreds. Also, indoor cats, especially those that are housed alone, generally reach puberty later than do outdoor cats. A British study of several breeds reported that the average age at puberty was between 9 and 10 months, but there were considerable differences among breeds. Himalayans and colorpoints were the oldest at puberty, averaging 13 months, and Burmese were the youngest, averaging 7.7 months.

The Estrous Cycle

The natural breeding season for cats in temperate zones usually begins twenty to sixty days after the winter solstice and may end any time after the summer solstice. The queen is seasonally polyestrous (i.e., she is receptive to the male several times within a breeding season). In conditions of artificial or natural light, many queens will cycle throughout the year if they are exposed to twelve to fourteen hours of light a day. Installing a timer is an efficient way to control the amount of artificial light in a breeding cattery.

If not mated, most queens will have nonovulatory estrous cycles throughout a breeding season. The cycle then consists of waves of ovarian follicles producing estrogen, followed by degeneration of those follicles and an interestral period but no luteal or metestrous period. That situation results in periods of behavioral estrus interrupted by periods of sexual nonreceptivity.

The estrous cycle and interestral periods are quite variable. Proestrus lasts for up to three days, followed by an estrus of three to twenty days (the average is seven or eight days). The interestral period lasts three to fourteen days; it averages nine to thirteen days during the breeding season but can be as long as thirty days. Thus, the length of an unbred queen's cycle (the interval from onset of one estrus to onset of the next) can range from seven to forty days; most cycles last twelve to twenty-two days.

Vaginal Cytology

Vaginal cytology can be used to characterize the queen's estrous cycle. Vaginal cells for cytologic evaluation can be collected with a moistened sterile cotton swab (3-mm diameter) or a clean glass eyedropper. For collection, the swab or eyedropper is passed into the vagina about 1 to 1.5 centimeters by first inserting it into the vestibule in a dorsally directed manner until resistance is met, then redirecting it horizontally to advance it into the anterior vagina. That ensures that the clitoris and clitoral fossa are not entered or irritated.

To collect vaginal cells the moistened swab is rotated several times in the vagina, or about 0.25 milliliters of sterile physiological saline in an eyedropper is flushed two or three times in the vagina. The swab is then rolled on a clean glass slide, which is then immediately fixed in alcohol or air dried, or fluid from the eyedropper is placed on a glass slide and allowed to air dry. The slide is then stained with either a cytologic or a hematologic stain. The slides should be kept as a reference of changes that occur throughout the estrous cycle. Smears of vaginal cells should be done daily or every other day when looking for changing cell types to differentiate the stages of the estrous cycle (see table 1). The vaginal swabbing or flushing may induce ovulation in some queens in estrus. If the queen does not ovulate, the cytology will normally regress to an anestrous type, and noncornified epithelial cells will appear.

Red blood cells normally should not be present in the queen's vagina during any stage of the estrous cycle. If they are, the most-common causes are that trauma to the vaginal cavity occurred when taking the cytologic sample, the queen has a genital-tract infection, or the sample was taken in the early postpartum period.

Inducing Estrus

Induction of estrus in a queen can be accomplished by lengthening the daily light cycle to which she is exposed, socializing the queen with other cycling queens, exposing her to a tom, or giving her hormonal therapy.

Various hormonal regimens have successfully induced queens into estrus. Colby reports an 80 percent efficiency rate when using gonadotrophins. However, that method works best on queens between the ages of one and five years. Colby's treatment consists of an initial dose of 100 international units (IUs) of pregnant mare's serum gonadotrophin (PMSG) given intramuscularly (IM). That is followed by a lower daily dosage, given on seven consecutive days, of either 25 IUs or 50 IUs, depending on the season (Colby administered the lower dose when treatment occurred between February and August). When estrous behavior becomes apparent, the dose is reduced to 25 IUs to prevent overdosage.

Another method, which produces results comparable to those of natural breeding, uses a single injection of 100 IUs of PMSG, followed in seven days by an injection of 50 IUs of human chorionic gonadotrophin (HCG). A third method uses follicle stimulating hormone from pituitary extracts (FSH-P) to induce estrus. A dosage of 2 milligrams of FSH-P is administered IM daily for five days or until the queen shows signs of estrus. On days one and two of estrus, 250 IUs of HCG are given IM to enhance ovulation. The queen should then be bred at least four times on each day of estrus for a period of up to four days. That regimen successfully produced litters even when using frozen cat semen.

Estrogens (50 mcg of estradiol benzoate or 0.25 mg of estradiol cypionate, given IM and repeated in forty-eight hours) will induce false estrus in most queens. To avoid causing toxicity or extreme bone-marrow suppression in a queen, no more than 8 milligrams of estrogen should be administered within any continuous four-month period. Testosterone (20 mg/day IM) has also been reported to induce estrus in queens.

However, using gonadotrophins to induce estrus in queens may inadvertently lead to the queen's producing waves of ovarian follicles that may contain immature ova and cause cystic follicular degeneration. Also, excessively long estrous periods, lasting two to four weeks, may occur following administration of either gonadotrophins or sex-steroid hormones unless natural or artificial mating is provided.

The estrous behavior of queens receiving hormonal therapy should be evaluated daily by a handler or by observing the queen's response in the presence of an experienced tom. Studies indicate that queens in which estrus has been induced can produce litters of normal size.

Figure 1

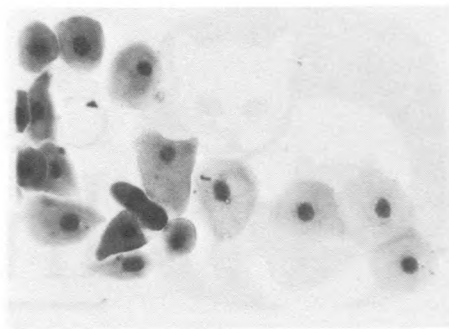

Figure 2

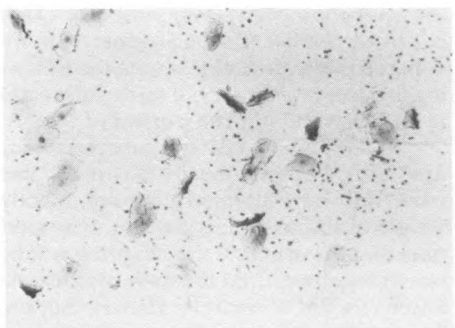

Figure 3

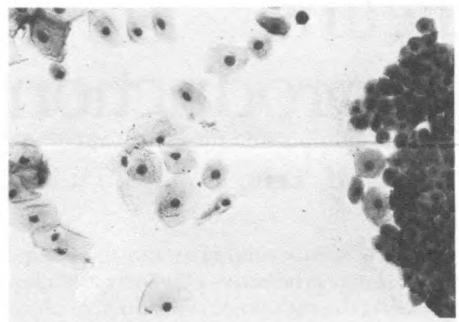

Figure 4

Table 1. Vaginal Cytology

Anestrus	Numerous small round epithelial cells with a high nuclear: cytoplasmic ratio are present (see figure 1). Occasionally polymorphonuclear leukocytes are visible. There is increased debris.
Proestrus	An increased number of intermediate epithelial cells are present. Cornified epithelial cells begin to appear more frequently before estrus occurs. There is a decrease in nucleus size and an increase in cytoplasm. There is also increased debris. (See figure 2.)
Estrus	The smear is dominated by polyhedral cornified epithelial cells with curled edges (see figure 3; the blood cells are present because of trauma inflicted on the vaginal mucosa while obtaining the specimen). Because the vaginal fluid is watery, there is less debris compared with the other stages of the estrous cycle. Polymorphonuclear leukocytes are absent.
Metestrus	After ovulation, cornified epithelial cells are still present, but the margins are less defined (see figure 4, left). Occasionally numerous bacteria and polymorphonuclear leukocytes are present. During late metestrus there is an increase in smaller basophilic epithelial cells (see figure 4, right).

Sexual Behavior and Mating

Pheromones are involved in the sexual behavior and mating of cats. During a queen's estrus, valeric acid is present in vaginal secretions that act as a sexual pheromone to toms. Only sexually mature queens respond to odor from a tom's urine spraying by exhibiting estrous behavior. It is thought that cats' sensory receptors for pheromone detection are located in the vomeronasal organ, a blind pouch situated dorsal to the hard palate, which communicates with the nasal and oral cavities via the nasopalatine duct.

Estrous behavior by a queen in the absence of a tom usually includes persistent vocalization, rolling, rubbing, extreme affection, and—at variable frequency and intensity—treading of the hind legs, lordosis, and tail deviation. A slight anterior and lateral positioning of the ears is common, as is an intense facial expression, similar to that seen in aggression or fright. A repeated monotonic crying or howling for as long as three minutes at a time may occur, perhaps accompanied by treading and rolling. The estrous howl is given by

the queen when she is in estrus and in the presence of a tom. The queen's "appeasement" howl stimulates the tom to mount. Restlessness, general uneasiness, and pacing back and forth may accompany any of the behavior patterns described above. A general loss of appetite in both the queen and the tom often occurs during the breeding season.

Some estrous queens may exhibit most of the behavioral signs of estrus only when exposed to a tom or when checked for estrus by handling. Treading, lordosis, and the typical mating stance with lateral deviation of the tail can be evoked by stroking the flanks, the back, the thighs, or the perineum. Rubbing or scratching the back of the neck or the shoulders induces treading but usually not the mating stance. The ears' positioning and the facial expression may be induced by all of those manipulations. In addition, handling and stroking an estrous queen may provide enough neural stimulation to cause ovulation.

The mating sequence usually involves the biting of the queen's neck by the male, followed by mounting and pelvic thrusting until penile intromission occurs. The mating scream, or cry, which is emitted by the queen at the time of penile intromission, was once thought to be pain caused by the penile spines. However, that reaction can be elicited in estrous or anestrous queens, intact or spayed, with any instrument that invades the vaginal and cervical area. Intromission is brief, lasting two to twenty seconds. Immediately following intromission, the queen frees herself from the male and interrupts bouts of rolling and rubbing with licking of the external genitalia. The tom usually stays nearby, watching the queen and preventing her from mating with other toms. If the queen mates with a free-roaming tom, other toms may subsequently challenge him and also mate with the queen, resulting in a litter sired by more than one tom (superfecundation). Early in the estrous period, most queens will copulate again in ten to fifteen minutes. In one study, copulation occurred twenty to thirty-six times during a thirty-six-hour observation period; it was more frequent during the first two hours (three to six copulations) than in any subsequent two-hour period.

The relative body size of the tom and the queen may influence the success of mating. Queens that are too large or too small may make it difficult to achieve a successful rapid mating and can result in a frustrated, unsuccessful tom. That is especially a problem with young or timid toms that are placed in a mating situation by a breeder. The activity of the tom's attempting to breed a queen, however, may be enough to induce ovulation even in the absence of intromission and ejaculation and, consequently, semen for fertilization.

Table 2. Reproductive Endocrinology

Luteinizing hormone	Released during mating. Ovulating cats have levels of 17 ± 2 ng/ml, whereas nonovulating cats have levels of 8 ± 2 mg/ml.
Progesterone	At baseline level (1ng/ml or lower) during first 2 or 3 days of pregnancy but detectable thereafter. The level continues to increase until day 21, when the average level is 10 ng/ml. After day 21 it decreases, to 4–5 ng/ml before parturition. After parturition the hormone level drops to 1 ng/ml or lower. Pseudopregnant queens have a similar increase; however, by day 30 the level begins to decline.
Estradiol	On the day of mating the level is about 60 pg/ml. During the next 5 days it decreases rapidly, to 8–12 pg/ml. That level is maintained until parturition, when a slight increase occurs. Pseudopregnant cats follow a similar course, but a more-rapid decrease follows mating.
Prolactin	Levels are elevated in the last trimester of pregnancy. The average is 31.2 ± 5.1 ng/ml through the last week of pregnancy; then it increases to 43.5 ± 5.4 ng/ml during the last 3 days before parturition. About 2 weeks after weaning, prolactin declines to prelactation levels.

Ovulation

Ovulation in the queen depends on the release of sufficient amounts of luteinizing hormone (LH) from the anterior pituitary gland. Since the queen is an induced, or reflex, ovulator, LH is released in a neural reflex initiated by vaginal-cervical stimulation during mating. Probably luteinizing hormone–releasing hormone (LH-RH) is first released from the hypothalamus following intromission, which results in release of LH from the anterior pituitary gland. LH levels in the queen fluctuate episodically; increases occur every twenty to thirty minutes and are probably under the influence of the episodic release of LH-RH.

Ovulation usually occurs within twenty-five to thirty hours after mating if sufficient LH has been released; some investigators have reported the occurrence of ovulation up to fifty hours after mating. The variances may be due to the queen's individual threshold levels of LH-RH and LH, the number of days the queen has been in estrus when mated, immaturity of the ovarian follicles, or the number of intromissions required by a queen for adequate release of LH. It appears that some queens will not release an ovulatory amount of LH until the second, third, or even fourth day of estrus. Therefore, the best time to breed queens is on the second or third day of estrus, and at least four matings should occur to ensure that the queen releases adequate LH and achieves maximal ovulation.

Ovulation can be induced in estrous queens by artificially stimulating the vaginal walls or cervix with a probe; just as multiple intromissions do, multiple probings repeated at five- to fifteen-minute intervals will enhance the release of adequate LH. Injecting both anestrous and estrous queens with exogenous LH-RH (25 mcg) causes LH release and results in ovulation during estrus. Ovulation will also occur in estrous queens within twenty-six or twenty-seven hours after administering 25 to 50 IUs of HCG. Fertilization rates for natural matings are almost 100 percent for up to twenty-seven hours after administering the HCG but decline to between 35 and 80 percent during the period of thirty hours to forty-nine hours after treatment. Conceptions can occur fifty-two or more hours after HCG administration, indicating that the fertile life of the queen's ova after ovulation is about twenty-four hours. Some investigators have demonstrated that a single injection of 500 IUs of HCG, or an injection of 250 or 500 IUs of HCG on two consecutive days of estrus, produced a significant increase in the percentage of ovulation rates in comparison to the percentage achieved by a single injection of 50 or 100 IUs of HCG.

Pregnancy

Gestation lasts sixty-four to sixty-nine days (the average is sixty-six days). Breeders often depend on the physical change of the queen's nipples from light pink to rosy pink in the second and third weeks following mating as an indication of pregnancy. Pregnancy diagnosis is best accomplished, however, by careful abdominal palpation of the uterus from days seventeen to twenty-five, when the conceptus is round and segmented from other conceptuses. After thirty to thirty-five days the elongated fetus and fetal membranes become confluent, and it is difficult to distinguish pregnancy from an enlarged uterus caused by pseudopregnancy or pyometria.

The mineralized opaque fetal skeleton

will show on abdominal radiographs from the fortieth to forty-fifth day of gestation to term. The approximate gestation age can be estimated by the radiographic appearance of mineralized bone in the fetus—at forty-one days the radius and ulna are visible; at forty-three days the tibia, fibula, ilium, ischium, and occipital bones of the skull can be seen; at fifty-five days the entire skeleton is visible.

A phenomenon known as pseudopregnancy can occur in queens. In fact, a queen can have as many as five pseudopregnancies in a breeding season. Elevated progesterone levels occur in pseudopregnant queens at the same time in the estrous cycle—days ten to twelve—that implantation of the fertilized ova occurs in a pregnant queen. Within about forty days of its onset, the pseudopregnancy will terminate as progesterone levels return to prebreeding levels. Ovarian activity is reestablished within seven to ten days after the end of a pseudopregnancy.

Parturition

The endocrinology (see table 2) and physiology of parturition in the queen have not been fully studied. A few days before parturition, the queen experiences a decrease in circulating progesterone to prepregnancy levels and an increase in estradiol-17B levels. Then the estradiol level drops on the day of parturition as circulating prolactin levels increase. The endogenous effects and levels of prostaglandins, relaxin, cortisol, and oxytocin are unknown. Clinically, administration of oxytocin is very effective in causing uterine contractions to end uterine inertia, expel retained kittens or placentas, and initiate milk let-down. Probably endogenous oxytocin is present. The queen will also react to "feathering" the vagina during parturition, resulting in uterine contractions.

The rectal temperature falls in the first stage of labor. The second stage of labor is usually quite rapid; there are a few abdominal strains, similar to defecation, before the first kitten is delivered. The third stage—placenta expulsion—closely follows the fetal delivery.

Summary

The cat is unique among mammals in some aspects of reproductive physiology and endocrinology. This article discusses the generalities of feline puberty, estrous cycles, sexual behavior and mating, pregnancy, and parturition. More-detailed information can be obtained from the references listed below.

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The ultimate purpose of the Cornell Feline Health Center is to improve the health of cats by developing methods to prevent or cure feline diseases and by providing continuing education to veterinarians and cat owners. The Cornell Feline Health Center is a nonprofit organization supported largely by private tax-deductible contributions. Correspondence may be directed to:

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