Animal Reproduction Science 124 (2011) 200–210

Contents lists available at ScienceDirect

Animal Reproduction Science

journal homepage: www.elsevier.com/locate/anireprosci

Reproductive cycles of the domestic bitch☆

Patrick W. Concannon*

Department of Biomedical Sciences, College of Veterinary Medicine, Cornell University, Ithaca, NY 14850, USA

ARTICLE INFO

Article history:
Available online 8 October 2010

Keywords:
Estrus
Anestrus
Progesterone
LH
GnRH
Corpus luteum

ABSTRACT

Domestic dogs are monoestrous, typically non-seasonal, polytocous, spontaneous ovulators and have a spontaneous luteal phase slightly longer (by approx 5 day) than the 64 ± 1 day luteal phases of a 65 ± 1 day pregnancy, a phase followed by an obligate anestrus before the next 2–3 week "heat" (proestrus-estrus). The resulting inter-estrus intervals of 5–12 months are variable among bitches, commonly 6–7 months, and range from highly variable to regular (to perhaps within ± 5–10 day of sequential 7 month cycle, for instance) within bitches, and across studies and do not vary significantly between pregnant and non-pregnant cycles. Hormone levels reported are those observed in this laboratory using previously reported assays and canine gonadotropin standards unless stated otherwise. Endocrine sequences for dog cycles are not unlike those of many other mammals, including selection of ovulatory follicles by increased LH pulsatility, the occurrence of estrus behavior and LH surge during a decline in the estrogen: progestin ratio, a pronounced preovulatory luteinization as in humans and rodents, and luteotrophic roles for both LH and prolactin. Non-pregnant bitches have a spontaneously prolonged luteal phase, often longer and with a more protracted decline in serum progesterone than in pregnancy as there is no uterine luteolytic mechanism. The obligate anestrus of 8–40 weeks is terminated by poorly understood interactions of environment (e.g. pheromones, possibly photoperiod) and a potential endogenous circannual cycle in sensitivities of hypothalamic dopaminergic, serotonergic and/or opioid pathways.

1. Introduction

Bitches are monoestrous, typically non-seasonal, polytocous, spontaneous ovulators and have a spontaneous luteal phase similar in length to or a bit longer than the 64 ± 1 day luteal phase of the 65 ± 1 days of pregnancy followed by an obligate anestrus before the next 2–3 week "heat" period (Table 1). Inter-estrus intervals of 5–12 months, typically 6–7 months, range from highly variable to regular within bitches, and averages do not vary significantly or consistently between pregnant and non-pregnant cycles. Pubertal estrus occurs variably at 6–14 months in most breeds, with means positively correlated with breed size. The canine cycle is classically divided into 4 phases (Evans and Cole, 1931)—a 5–20 day proestrus, 5–15 day estrus, 50–80 day metestrus (post-estrus portion of luteal phase), and anestrus typically lasting 80–240 days. These phases reflect, respectively, follicular phase rise in estrogen, the initial luteal phase rise in progesterone and decline in estrogen, the remainder of the luteal phase, and the interval between loss of luteal function and onset of next cycle. Timing within the 160–370 day cycle has been variably reported in days post proestrus onset, estrus onset, metestrus onset, preovulatory LH peak or LH surge. The latter is used as day 0 in this review (Fig. 1) unless otherwise noted. Levels of hormones are primarily those observed in the author's laboratory using previously reported assays and canine gonadotropin standards.

☆ This paper is part of the special issue entitled: Reproductive Cycles of Animals, Guest Edited by Michael G Diskin and Alexander Evans.

* Tel.: +1 607 257 4152.
E-mail address: pwc1@cornell.edu

0378-4320/$ – see front matter © 2010 Published by Elsevier B.V.
doi:10.1016/j.anireprosci.2010.08.028

Table 1
Selected features of normal ovarian cycles of domestic dogs.

Parameters and features	Nature, condition or description	Range, duration, or incidence	Average	Comments
Cycle (intervals)	Monoestrus. Polytocous. Non-seasonal	5–12 mo	7 mo	Basenji is seasonal (autumn estrus)
Preovulatory LH surge	Spontaneous	1–3 d	2 d	Onset is "Day 0" of cycle
Onset of surge release of LH	Sufficient to stimulate ovulation	Day 0	1 d	Onset is "Day 0" of cycle
Proestrus signs, behavior	Spontaneous	5–20 d	9 d	Estradiol (E2) increasing
Estrus behavior	Spontaneous	6–11 d	9 d	Declining E2, increasing P4
Estrus behavior onset	Variable	Day −2 to +5	Day 1	Preovulatory luteinization at LH surge
Ovulation	Spontaneous	~60 h post LH surge	–	Nearly synchronous among follicles
Oocyte maturation	Postovulatory, in distal oviduct		Day 4	Estimated at 48–60 h post ovulation
Progesterone first >1 ng/ml	Concomitant with LH surge	Day 0 to +1	Day 0	Used to predict Day 2.5 ovulation
Loss of oocyte viability	Variable among bitches	Day 6–10	Day 7	Estim. in timed-breeding studies
Fertile insemination possible	Including vaginal AI	Day −3 to 10	–	3–7 d survival of uterine sperm
Fertile breeding possible	Natural mating	Day −3 to 8	–	Rarely Day 10
Apparent "cervical closure"	Barrier to natural insemination	Day 7–10	Day 8	Based on AI and contrast studies
Peak fertility	Natural mating	Day 0–5	–	
Peak fertility	Frozen-thawed semen	Day 5–6	–	
Peak vaginal cornification	Vaginal cytology	Day −5 to +1	Day −3	Not clinically useful to time ovulation
Metestrus onset	"Metestrus" vaginal smear	Day 6–10	Day 7 or 8	"Diestrus-1; D1; Metestrus-1; M1" terms used
Metestrus or Diestrus (NP)	Post-estrus luteal phase	45–70 d	60 d	Terms are synonymous in bitch
Luteal phase	Nonpregnant cycles	Day 0 to Day 55–80	to Day 70	Progesterone above 1.5 ng/ml
Luteal phase	Pregnant cycles	Day 0 to Day 62–65	to Day 64 ± 1 d	Parturition Day 65 ± 1 d
LH luteotrophic	Experimental evidence	Day 13–55	–	LH likely luteotrophic throughout
Prolactin Luteotrophic	Experimental evidence	Day 13–55	–	PRL likely luteotrophic throughout
Luteolytic protocols	PGF b.i.d.; PGF-Ag and/or DA-Ag q.d.	Day 25–30 onward	–	Given "to effect" (4–9 d for PGF)
Pregnancy-specific PRL rise	Concomitant with relaxin rise	Day 25–28	Day 27	Significant by Day 30–32
Obligate Anestrus	From P4 < 1 ng/ml until next Proestrus	3–10 mo	5 mo	Avg. longer in some large breeds
Estradiol peak	Late proestrus	Day −3 to 0	Day −1	40–110 pg/ml vs. 5–20 pg/ml in anestrus
Progesterone peak	Early metestrus	Day 20–30	Day 25	15–80 ng/ml vs. 0.5 ng/ml in anestrus
Luteal regression period	Mid and late metestrus; slow, progressive	45–60 d, e.g. Day 25–70	–	Hysterectomy has no effect
Pre-PE LH-pulse rate increase	Circhoral, 60–90 min intervals	Day −35 to −15	8–10 d. pre-proestrus	Duration of 6–10 d, estim.

Notes: LH (luteinizing hormone); d = day(s); Day (day of cycle relative to Day-0 LH surge); NP = nonpregnant; PRL = prolactin; E2 = serum estradiol; P4 = serum progesterone; PGF = prostaglandin F2 alpha; DA = dopamine; Ag = agonist.

This review is based on reports and reviews from this laboratory (Concannon, 1989, 2009; Concannon et al., 1975, 1979, 1980, 1997a,b, 2001a,b, 2006a, 2009) and from, among others, researchers in Osaka (Hatoya et al., 2003); Tsutsui et al. (2007, 2009) in Tokyo; Hoffmann and Kowalewski and colleagues in Giessen and Zurich (Kowalewski et al., 2007); Verstegen, Onclin and colleagues (Verstegen et al., 1999) in Gainesville; England et al. (2009a,b) in Nottingham; Okkens, Kooistra, Rijnberk and colleagues in Utrecht (de Gier et al., 2008); Gobello and colleagues, Wildt and colleagues (Wildt et al., 1981), researchers at Ghent (Van Cruchten et al., 2004), Fontbonne, Reynaud, and colleagues at Alfort (Reynaud et al., 2006), and Nett, Olson and colleagues at Colorado State (Fernandes et al., 1987), as well as reports in ISCFR symposia Proceedings (see Concannon et al., 1989, 1993, 1997a, 2001a,b, 2006b; England et al., 2009a). Important classical texts include Evans and Cole (1931), and Andersen and Simpson (1973).

2. Endocrinology

Endocrine mechanisms of the canine cycle are not unlike those of other mammals as interpreted from hormone profiles and results of experimental manipulations. Steroid assays established for ruminants and humans have been adapted to canine serum and plasma using sample extraction or direct assays with samples from ovariectomized animals controlling for non-specific interference. LH, FSH and prolactin are assayed using either heterol-