Review Article

Updated Reproductive Hormonal Profiles in Female Elephants

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Abstract

Through advances in endocrine monitoring and ultrasonographic examination, we have understood some of the complex mechanisms controlling reproductive function in elephants. Several reproductive characteristics appear to be unique such as luteal steroidogenic function, follicular development patterns, pituitary gonadotrophin secretion, and long estrous cycle and gestation lengths. This review describes current knowledge of female elephant endocrinology and how it is being used for maximal reproductive efficiency and enhancement of proper management.

Keywords: corpus luteum, estrous cycle, female elephants, hormones, pregnancy, ultrasonography

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Overview of reproductive endocrinology in female elephants

Endocrinology of the estrous cycle

1. Inhibin: Inhibin is a glycoprotein hormone secreted from ovaries and testes, consisting of three inhibin subunits, common α- and βA (inhibin A) or βB (inhibin B) - subunits (Burger, 1988). Inhibin is secreted from granulosa cells of follicles in the ovary in most of females and specifically suppresses the secretion of follicle-stimulating hormone (FSH) from the pituitary gland to regulate the ovarian activity in females (Taya, 1993; Medan et al., 2007). Corpora lutea (CL) also secrete inhibin in monkeys (Watanabe et al., 1990), women (Yamoto et al., 1991), and goats (Kandiel et al., 2010). Previous reports have shown that the serum inhibin levels were parallel with progesterone throughout the estrous cycle in Asian elephants (Brown et al., 1991, 1999; Kaewmanee et al., 2011). Kaewmanee et al. demonstrated that the immunolocalization of inhibin α, βA, and βB subunits were detected in both granulosa cells of antral follicles and luteal cells in the ovary of an Asian elephant (Kaewmanee et al., 2011). These findings strongly suggested that CLs and follicles were the source of circulating inhibin during the estrous cycle in Asian elephants.

2. Luteinizing Hormone (LH): LH is secreted by the anterior pituitary gland and reaches its maximum shortly before ovulation in most of mammals. In elephants, however, it was noted that the LH activity was different. Daily sampling during the follicular phase has revealed that the elephant exhibits two LH surges, referred to as the “double LH surge” (African: Kapustin et al., 1996; Asian: Brown et al., 1999). The first surge occurs 10-20 days after the drop of progesterone, then the second surge occurs 19-22 days later.

The surges are quantitatively and qualitatively similar, but only the second induces ovulation. The terms anovulatory LH (anLH) and ovulatory LH (ovLH) are used to define these surges, which follow each of two functionally distinct follicular waves (Hermes et al., 2000). During the follicular phase, the interval between the return in progestagens level to baseline and the anLH surge varied in length (25.4±1.2 days), and was longer in the rainy season (33.4±1.8 days) than in the winter (30.2±1.4 days) and summer (18.9±2.6 days) in semi-captive Asian elephants in Thailand (Thitaram et al., 2008). Based on correlations between ultrasonographic and endocrine measurements, Lueders et al. (2011) investigated physiological roles of two LH surges and accessory corpora lutea (acCL) on follicular development in the ovary during the estrous cycle in Asian elephants. Ultrasonography demonstrated that there were two follicular waves during the follicular phase but follicular development was not observed during the luteal phase. The first and second LH surges took place at the end of the first and the second follicular waves, respectively. After the anLH surge, large follicles remained as luteinized follicle (LUF) while small follicles regressed. These LHF became acCL, but maintained an anechoic central cavity up to 3 weeks after ovulation. The regression of acCL set before a decline in diameter of the ovulatory corpus luteum (ovCL) was noticeable. The ovulatory follicle formed in the ovary having a large number of LUF/acCL. Circulating immunoreactive (ir-) inhibin increased after the anLH surge and this was coincident with the ultrasonographically visible luteal tissue formation. These results suggest that LUF/acCL are a major source of circulating ir-inhibin, and inhibin and activins may regulate follicular development and luteal function in the elephant ovary.

3. Follicle stimulating hormone (FSH): Circulating concentrations of FSH decline after the selection of dominant follicles in each wave and the resulting secretion of inhibin and/or estradiol (Kaneko et al., 1995). For the elephant, FSH secretion seems to follow a different pattern.

Its concentrations reach their maximum at the beginning of the follicular phase and then declined steadily to a minimum within 4 days of the ovulatory LH surge. Concentrations remain basal until after the ovLH surge and then increase during the early luteal phase followed by a relatively long period of increased concentrations lasting for at least 7-8 weeks that covers the late luteal and early follicular phases (Brown et al., 1999). Kaewmanee et al. (2011) also demonstrated that there was a negative correlation between FSH and ir-inhibin patterns during follicular and early luteal phases, whereas there were no significant correlations in any other period during the whole estrous cycle. These findings imply a single, prolonged, stimulation for follicular development of the two waves over most of the inter-luteal period.

4 Prolactin (PRL): A notable species difference exists for prolactin secretion; concentrations increase during the follicular phase in African (Brown et al., 2004), Yamamoto et al. (2011) but not in Asian (Brown et al., 1999, 2004) elephants. Thus, overall average prolactin concentrations are higher in African than Asian females. Elevated PRL to pathological concentrations (hyperprolactinemia) in African elephants were linked to an ovarian dysfunction (Yamamoto et al., 2011).

Endocrinology of the pregnancy

The circulating PRL levels showed a biphasic pattern during pregnancy in elephants; circulating PRL levels started to increase in the 6th month of gestation, reaching its first peak in 11-14th month, followed by the second peak within 18-20th month of gestation, before an abrupt decline prior to parturition. Conversely, the second peak was not observed in the case of abortion in the African elephant. Furthermore, immunoreactive (ir-) PRL was detected in the homogenate of term placentae of African and Asian elephants, and immunoreactivity was observed in the syncytiotrophoblasts of the Asian elephant. The circulating cortisol concentrations remained unchanged throughout gestation period; however, remarkable increases were observed 5-10 days before parturition in the African elephant and
30-40 days before in the Asian elephant. The present study demonstrated the biphasic pattern of circulating PRL during pregnancy and the presence of ir-PRL in the term placenta in African and Asian elephants. These results suggested that the placenta was one of the major sources of PRL during pregnancy in elephants. Remarkable increase in circulating cortisol before parturition suggested that hypothalamus-pituitary-adrenal axis was activated, or cortisol had any role on parturition like other species (Yamamoto et al., 2010).

Circulating levels of ir-inhibin started to increase at 1 or 2 week before the ovulation and reached the peak level 3 or 4 weeks earlier than progesterone during the estrous cycle in both African and Asian elephants. After last luteal phase, the serum levels of ir-inhibin remained low throughout pregnancy in both African and Asian elephants. The mean levels of ir-inhibin during the pregnancy were lower than the luteal phase in the estrous cycle despite high progesterone levels were maintained throughout the pregnancy. These results strongly suggest that CL secretes a large amount of progesterone, not inhibin, during the pregnancy in elephants (Yamamoto et al., 2011).

**Conclusion**

Endocrine monitoring is one of the key points to assess reproductive status of elephants. Although we have clarified a broad understanding of elephant endocrinology, a lot of information gaps still remain. Future researches must focus on innovative works to improve basic knowledge while using technology to support in situ and ex situ conservation projects. Also, it is important to compare an extrapolating data across species. Even though there are many similarities in endocrine function between Asian and African species, there are enough differences to conduct comparative studies on all aspects of reproductive biology.

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**References**


