REPRODUCTIVE HORMONES AND THEIR ROLE IN FARM ANIMAL REPRODUCTION

Diksha Upreti[1], Shruti Dehru[2], Siraj Ansari[2], Neha Kumawat[2], M.H. Khan[1]
Division of Animal Reproduction, ICAR- Indian Veterinary Research Institute, Izatnagar, Bareilly, India, Division of Medicine, ICAR- Indian Veterinary Research Institute, Izatnagar, Bareilly, India
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ABSTRACT

Reproductive hormones play a vital role in the management of farm animal reproduction by regulating physiological processes such as follicular development, ovulation, pregnancy maintenance, and parturition. Hypothalamic hormones like gonadotropin-releasing hormone (GnRH) regulate the secretion of follicle-stimulating hormone (FSH) and luteinizing hormone (LH), which are essential for ovulation and spermatogenesis. Hormones such as oxytocin, progesterone, estrogen, and prostaglandins contribute to uterine contractions, lactation, and the maintenance of pregnancy. Advanced reproductive techniques such as estrus synchronization, superovulation, and the induction of ovulation utilize these hormones to optimize fertility, increase breeding efficiency, and improve genetic potential. Species-specific responses, dosage, and the method of administration significantly influence the efficacy of hormonal treatments. The integration of hormonal strategies in breeding programs has revolutionized livestock management, enhancing reproductive success and productivity.

Keywords: Hormones, Estrus, Ovulation, Fertility, Lactation, Management.

INTRODUCTION

The use of reproductive hormones in farm animals has revolutionized the management of animal breeding and reproduction, significantly enhancing the productivity and efficiency of livestock farming. Reproductive hormones play a crucial role in regulating various physiological processes such as estrous cycles, follicular development, ovulation, pregnancy maintenance, and parturition. Understanding the intricacies of these hormones and their physiological functions is essential for optimizing reproductive strategies and ensuring sustainable production in farm animals. The major groups of reproductive hormones, including pituitary, hypothalamic, ovarian, placental, uterine, hormones, are key regulators of reproductive events. Their precise manipulation has allowed for significant improvements in breeding programs, such as estrus synchronization, ovulation induction, superovulation, and pregnancy

Maintenance (Gundling et al., 2012). Additionally, we examine factors affecting hormonal efficacy, recent advances in hormonal applications, ethical considerations, and the future prospects of hormonal interventions. The ability to control and regulate reproductive processes through hormonal therapies has not only boosted animal fertility rates but also minimized the incidence of reproductive disorders, ensuring healthier herds and improved productivity (Bó&Mapletoft, 2014). However, it is crucial to carefully address challenges associated with hormone misuse and residue concerns to ensure ethical and safe practices in farm animals.

REPRODUCTIVE HORMONES IN FARM ANIMALS

Hypothalamic Hormones

Gonadotropin-releasing Hormone (GnRH)

Origin: GnRH is synthesized and secreted by the hypothalamus in the brain.

Mechanism of Action: GnRH acts on the anterior pituitary gland by binding to specific GnRH receptors, stimulating the release of FSH and LH. This process regulates the entire reproductive cycle in both males and females.
Function: GnRH serves as the master regulator of the reproductive system, as it directly influences the secretion of FSH and LH, which control gonadal function and the estrous cycle.
Role: Without GnRH, the anterior pituitary would not release FSH and LH, thus preventing ovulation and spermatogenesis. In reproductive management, GnRH is used in protocols for estrus synchronization, as it can trigger the release of LH and induce ovulation (Hassanein et al., 2024).

Oxytocin

Origin: Oxytocin is produced by the hypothalamus and stored in the posterior pituitary gland. It is released into the bloodstream during specific physiological events.
Mechanism of Action: Oxytocin binds to receptors on smooth muscle cells in the uterus and mammary glands. In the uterus, it stimulates uterine contractions, while in the mammary glands, it promotes milk ejection.
Function: The primary function of oxytocin is to facilitate childbirth by stimulating uterine contractions during labor. It also plays a key role in milk let-down, helping to expel milk from the mammary glands to the offspring(Chen & Sato, 2016).

Pituitary Hormones

Follicle-stimulating Hormone (FSH)

Origin: FSH is produced and secreted by the anterior pituitary gland in response to Gonadotropin-releasing hormone (GnRH) from the hypothalamus.
Mechanism of Action: FSH acts on the ovaries, binding to specific receptors on granulosa cells of the ovarian follicles. This binding triggers the growth and maturation of the follicles, particularly the primary and secondary follicles.
Function: The primary function of FSH in female farm animals is to stimulate follicular development and the production of estrogen by the granulosa cells. Role: FSH plays a vital role in regulating the estrous cycle. It also prepares the ovary for ovulation by ensuring the growth of a dominant follicle. Additionally, in artificial reproductive techniques like superovulation and embryo transfer programs, FSH is used to stimulate multiple follicles to increase the chances of successful fertilization (Gutiérrez-Reinoso et al., 2022).

Luteinizing Hormone (LH)

Origin: LH is also secreted by the anterior pituitary gland, triggered by the surge in GnRH from the hypothalamus.
Mechanism of Action: LH binds to the receptors on the theca cells of the ovarian follicles, leading to the final maturation of the follicle and triggering ovulation. In males, LH acts on the Leydig cells in the testes to stimulate testosterone production.
Function: In females, LH is crucial for triggering ovulation by causing the mature follicle to release the oocyte (egg). In males, it stimulates the production of testosterone, which is important for spermatogenesis.
Role: LH is essential for the successful release of the oocyte during ovulation and helps regulate the luteal phase by supporting the formation of the corpus luteum (CL), which secretes progesterone. Without LH, ovulation cannot occur, and reproduction would not be possible. In males, LH's role in testosterone production is vital for fertility and sexual function (Hossner, 2005).

Prolactin

Origin: Prolactin is produced and secreted by the anterior pituitary gland. Its secretion is stimulated by a variety of factors, including suckling, stress, and during pregnancy.
Mechanism of Action: Prolactin acts primarily on the mammary glands, where it binds to receptors on mammary epithelial cells, promoting their development and stimulating milk production after parturition. It also has regulatory effects on the gonads.
Function: The main function of prolactin is to initiate and maintain milk production (lactogenesis) in mammals after giving birth. It also helps in the maternal care of offspring

and can influence reproductive cycles by suppressing the secretion of GnRH.

Role: In farm animals, prolactin is crucial for lactation, ensuring that the mother can provide nutrition for her young. Additionally, prolactin plays a role in regulating the estrous cycle and reproductive processes by inhibiting ovulation during lactation, which helps prevent simultaneous pregnancy and lactation (Lacasse et al., 2016).

Ovarian Hormones

Estrogen

Origin: Estrogen is produced primarily by the granulosa cells of developing ovarian follicles, as well as the corpus luteum after ovulation.

Mechanism of Action: Estrogen exerts its effects by binding to estrogen receptors on various tissues, including the uterus, mammary glands, and hypothalamus. This binding leads to changes in gene expression and cellular activity, influencing reproductive behavior and function.

Function: Estrogen plays a central role in promoting the maturation of ovarian follicles, stimulating estrus behavior, and preparing the uterus for implantation. It also helps regulate the timing of ovulation and enhances the effectiveness of LH and FSH.

Role: Estrogen is key for initiating the estrous cycle and inducing sexual receptivity in females. In the context of reproduction, it primes the uterus for pregnancy by increasing uterine blood flow and stimulating the development of endometrial glands (Hossner, 2005).

Progesterone

Origin: Progesterone is primarily secreted by the corpus luteum after ovulation, and in early pregnancy, it is also produced by the placenta.

Mechanism of Action: Progesterone acts on the uterus by binding to progesterone receptors on the endometrial cells. This leads to the thickening of the uterine lining and a reduction in uterine motility, which is crucial for pregnancy maintenance.

Function: Progesterone prepares the uterus for the implantation of the fertilized egg and maintains a favorable environment for fetal development throughout pregnancy. It also inhibits further ovulation during pregnancy.

Role: Progesterone is the hormone of pregnancy. It is required to support the early stages of pregnancy by preventing uterine contractions, promoting endometrial development, and allowing the fertilized egg to implant and develop (Binder et al., 2015).

Inhibin

Origin: Inhibin is produced by the granulosa cells of ovarian follicles, particularly during the later stages of follicular development.

Mechanism of Action: Inhibin acts on the anterior pituitary to suppress the secretion of FSH, providing a negative feedback mechanism that prevents overstimulation of the ovaries.

Function: Inhibin's main function is to regulate the secretion of FSH from the anterior pituitary. This feedback loop ensures that only a limited number of follicles are recruited during each estrous cycle.

Role: Inhibin plays a critical role in regulating ovarian function by controlling the rate of follicular development, thus preventing excessive follicle recruitment and maintaining a balance in the ovarian reserve (Kaneko et al., 1997).

Activin

Origin: Activin is a glycoprotein hormone produced by various tissues, including the ovaries, placenta, pituitary gland, and gonads in both males and females. It is primarily synthesized in the granulosa cells of the ovaries in females and by other reproductive tissues. It is a member of the transforming growth factor-beta (TGF-β) superfamily.

Mechanism of Action: Activin exerts its effects by binding to specific activin receptors (ActR1, ActR2) located on the surface of target cells. Upon binding, this activates intracellular signaling pathways, primarily the SMAD proteins, which regulate the transcription of genes involved in folliculogenesis, cell growth, and differentiation. Activin also modulates the secretion of other hormones such as FSH and LH, influencing the reproductive process.

Function: Activin plays a crucial role in regulating the reproductive cycle and follicular development. It stimulates FSH secretion from the anterior pituitary gland, enhancing the recruitment and growth of ovarian follicles. Activin also has a role in embryonic development, placental development, and regulating the immune response during pregnancy.
Role: In farm animals, activin's main role is to regulate follicle-stimulating hormone (FSH) secretion and folliculogenesis (the development of ovarian follicles)(Li et al., 1995).

Placental Hormones

Placental Lactogen

Origin: Placental lactogen is produced by the placenta during pregnancy in species such as cattle, sheep, and goats.
Mechanism of Action: Placental lactogen acts on the mammary glands to stimulate their development and prepare them for milk production.
Function: Placental lactogen plays a role in promoting the growth of mammary tissue during pregnancy and stimulates milk production in preparation for lactation.
Role: In farm animals, placental lactogen ensures the mammary glands are ready for milk production following parturition, thereby enhancing the mother's ability to nourish her offspring (Hossner, 2005).

Relaxin

Origin: Relaxin is a peptide hormone primarily produced by the placenta in certain species such as pigs, cattle, and horses. In some species, it is also produced by the corpus luteum during pregnancy.
Mechanism of Action: Relaxin acts by binding to its receptors in the uterine and cervical tissues, as well as in the pelvic ligaments and pubic symphysis. It causes relaxation and softening of the connective tissues in the reproductive tract, particularly in the cervix and the pelvic ligaments, facilitating parturition.
Function: The primary function of relaxin is to facilitate parturition by relaxing the cervix, allowing it to dilate and ease the passage of the fetus during delivery. Additionally, relaxin helps to reduce uterine contractility during the early stages of pregnancy to prevent premature labor.
Role: Relaxin plays a critical role in the delivery process, specifically in preparing the reproductive tract for parturition. Its ability to soften and relax the cervix and pelvic ligaments ensures that the fetus can be delivered with minimal difficulty. In farm animals, relaxin's presence is essential for a successful, smooth birth. It is used in some veterinary practices to help induce or assist parturition in cases of dystocia (Sherwood, 2004).

Uterine Hormones

Prostaglandins (PGF2α)

Origin: Prostaglandins are produced by the endometrium (uterine lining) during the luteal phase of the estrous cycle.
Mechanism of Action: PGF2α binds to specific receptors on the corpus luteum, triggering luteolysis, which leads to a decrease in progesterone production and the initiation of a new estrous cycle.
Function: Prostaglandins are essential for regulating the estrous cycle. They promote the regression of the corpus luteum when pregnancy does not occur, and this leads to the initiation of a new cycle.
Role: Prostaglandins are commonly used in estrus synchronization protocols, as they help synchronize the cycle and induce estrus in farm animals, making breeding more predictable and efficient (Pereira de Moraes et al., 2021).

USAGE OF REPRODUCTIVE HORMONES IN FARM ANIMALS

Estrus Synchronization

Estrus synchronization is a critical technique in reproductive management that aims to control the timing of estrus in farm animals, enabling efficient breeding and improving reproductive efficiency. Protocols using PGF2α (Prostaglandin F2 Alpha), GnRH (Gonadotropin-Releasing Hormone), and progesterone are commonly employed in cattle, sheep, and goats to synchronize estrus.

PGF2α is used to induce luteolysis, leading to the regression of the corpus luteum (CL) and the onset of estrus. Progesterone is typically used to regulate the estrous cycle by either suppressing estrus or allowing a controlled return to estrus after removal(Gundling et al., 2012).

Induction of Ovulation

Induction of ovulation is a vital strategy for controlling breeding schedules and improving fertility rates in farm animals. hCG (Human Chorionic Gonadotropin)**,** GnRH**,** and LH (Luteinizing Hormone) are commonly used to induce ovulation, particularly in dairy and beef cattle, as well as in sheep and goats. hCG acts on the ovaries by mimicking the action of LH, stimulating ovulation and the formation of a mature corpus luteum. GnRH also plays a role by stimulating the anterior pituitary to release LH, which triggers ovulation. LH is directly involved in triggering ovulation, and its supplementation can increase the success rate of AI (Binder et al., 2015).

Superovulation

Superovulation is a process used to increase the number of ovulations in a single estrous cycle, which is particularly important for embryo transfer programs. FSH (Follicle-Stimulating Hormone) is the primary hormone used in superovulation protocols. FSH stimulates the development of multiple follicles in the ovaries, thereby enhancing the number of eggs available for fertilization. Superovulation, combined with artificial insemination or natural mating, allows for the production of genetically superior animals in livestock breeding programs(Bó&Mapletoft, 2014).

Pregnancy Maintenance

Progesterone plays a critical role in maintaining pregnancy in farm animals. Progesterone supplementation is commonly used to support **pregnancy maintenance**, especially in cases where early pregnancy failure is a concern or in situations where the corpus luteum is insufficient to sustain pregnancy. Progesterone is also used in synchronization protocols to prevent premature estrus and maintain pregnancy in animals undergoing assisted reproductive techniques such as embryo transfer (Mann et al., 2006).

Induction of Parturition

The induction of parturition, or labor, is sometimes necessary in farm animals for various reasons, including when there are risks of dystocia (difficult birth) or to synchronize births for management purposes. Oxytocin and prostaglandins (e.g., PGF2α) are key hormones used to induce parturition. Oxytocin stimulates uterine contractions, helping to facilitate the expulsion of the fetus and placenta during labor. It also plays a role in milk letdown after birth. PGF2α, on the other hand, induces luteolysis and helps prepare the uterus for labor by promoting uterine contractions. These hormones are crucial for managing the timing of parturition, improving calving rates, and ensuring timely delivery in cattle and other farm animals (Fuchs et al., 1996).

MANAGEMENT OF REPRODUCTIVE DISORDERS

Hormonal management is often employed to address common reproductive disorders in farm animals, such as cystic ovarian disease (COD) and anestrus (failure to return to estrus). In cases of cystic ovarian disease, hormonal treatments involving GnRH or hCG can be used to promote the luteinization of ovarian cysts, thereby restoring normal cyclicity and fertility. For **anestrus**, treatment with progesterone or GnRH is commonly used to stimulate estrus and restore ovarian function. In cases of repeat breeding, FSH and GnRH can be used to correct hormonal imbalances and improve fertility outcomes. These interventions are critical for enhancing reproductive efficiency and managing fertility in farm animal herds (Gundling et al., 2012).

CONCLUSION

In conclusion, reproductive hormones have proven to be invaluable tools in enhancing the reproductive efficiency of farm animals. By understanding the physiological roles and mechanisms of hormones, researchers and practitioners have developed advanced reproductive management strategies that have significantly improved breeding outcomes, fertility rates, and overall productivity. Hormonal interventions, including oestrus synchronization, induction of ovulation, super ovulation, and pregnancy maintenance, have revolutionized animal breeding, particularly in livestock industries such as cattle, sheep, and pigs. However, while the benefits of hormonal treatments are substantial, challenges remain, particularly concerning hormonal misuse, residues in animal products, and ethical concerns surrounding hormonal manipulation. These issues necessitate careful management, stringent regulations, and ongoing research to mitigate potential risks. As we move forward, it is crucial to continue exploring sustainable and ethical approaches to reproductive management in farm animals. Ultimately, the goal should be to balance animal welfare, environmental sustainability, and productivity, paving the way for more resilient and profitable farming practices.

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