Review Article:

FOLLICULAR DYNAMICS AND HORMONAL REGULATION DURING PHYSIOLOGIC BREEDING SEASON IN CYCLIC MARE

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ABSTRACT

This review synthesizes published information regarding equine follicular dynamics and endocrine regulation throughout the normal estrus cycle with a particular focus on follicular emergence, deviation, dominant follicle selection, preovulatory maturation, and ovulation. Literature was compiled from peer-reviewed journal articles, reviews, and equine reproduction textbooks concerning ovarian follicular development and hormonal regulation in mares during the breeding season. Available evidence suggests that there is a transient surge in follicle-stimulating hormone (FSH) driving a cohort of 6 mm follicles to grow together at roughly 2.8 mm daily prior to the onset of deviation occurring when the largest follicle reaches ~22 mm in major follicular waves, which is followed by a decrease in circulating FSH and an increase in intrafollicular insulin-like growth factor (IGF-1) activity, estradiol, inhibin, and luteinizing hormone (LH) responsiveness. The next steps of maturation of the dominant follicle (growing at rate of 3mm per day), competency of the ovulatory follicle (reaching a plateau of approximately 40-45mm) and induction of ovulation involve a coordinated interplay of gonadotropins, ovarian steroids and local intraovarian mediators. An understanding of these physiologic interactions is of direct clinical importance in the fields of estrus detection, timing of ovulation, reproductive ultrasonography, breeding management, and clinical decision making in the field of equine theriogenology.

Keywords: Deviation, dominant follicle, estrus cycle, follicular waves

INTRODUCTION

Mares are long-day seasonal breeders, highly responsive to the photoperiod; in the Northern hemisphere, the physiologic breeding season begins in the spring when day lengths increase, usually from April to September (Trundell, 2020). During the physiologic breeding season, mares normally exhibit regular spontaneous estrus cycles averaging 21 days, with a follicular phase of behavioural estrus (approximately 5–7 days) followed by a luteal (diestrus) phase of about 14 days (Crowell-Davis, 2007; Morel, 2020). The diestrus period ends with regression of the corpus luteum (CL) occurring due to secretion of prostaglandin $F_{2α}$ ($PGF_{2α}$) from the endometrium of the non-pregnant mare. Although average length of estrus cycle during physiologic breeding season is 21 days it can vary ranging from 18-24 days. This variation in the estrus cycle is typically due to the variation in estrus period rather than the diestrus period which varies from 3 to 9 days depending upon the season i.e. around 7 to 10 days during autumn and 4 to 5 days in the beginning of summer (Cortés-Vidauri et al., 2018; Morel, 2020). Transitional periods before and after the breeding season (spring and autumn transitions) cause irregular cyclicity or anestrus, and advancing age can further alter interovulatory intervals due to slower dominant follicle growth (Ginther et al., 2008; Spencer et al., 2022). These basic patterns lay the foundation to understand ovarian follicular dynamics and their hormonal regulation in cyclic mares.

Research on ovarian follicular dynamics during the normal estrus cycle in mares has emerged as a critical area of inquiry due to its fundamental role in equine reproductive physiology and its implications for breeding management and fertility optimization (Ginther et al., 2004; Raz & Aharonson-Raz, 2012). To achieve successful breeding management in mares, one must have accurate knowledge of the time of insemination or mating and match that with the time of ovulation, which depends on understanding the growth of the follicles and endocrine factors that control the selection, dominance and ovulation. Although the dynamics of the follicles have been described as waves and the involvement of gonadotropins, estrogens and prostaglandins (Bergfelt & Ginther, 1993; Ginther et al., 2004; Sirois et al., 2010), there are several practical and conceptual shortcomings. Over the past decades, advances in ultrasonographic techniques and hormonal assays have elucidated the wave-like patterns of follicular growth, selection, and ovulation, highlighting the complex interplay between follicular development and endocrine regulation (Bergfelt & Ginther, 1993; Sirois et al., 2010).

The overall goal of this review is to summarize and critically evaluate current knowledge of the follicular dynamics and associated hormonal changes that occur during the physiologic breeding season in cyclic mares, with particular focus on the patterns of follicular size changes during cycle days, and the endocrine correlates of follicular wave emergence, selection, dominance, and ovulation (El-Maaty & Abdelnaby, 2017; Medan et al., 2004; Spicer & Echternkamp, 1995). Studies of naturally cycling (not pregnant) mare of all ages and breeds conducted during the physiologic breeding season were included in the review. Eligible designs included both longitudinal and cross-section studies, controlled experimental, or clinical trials that provided measurements of the follicles and/or hormonal profiles across the days of the cycle; single-timepoint studies were excluded unless they provided data on time dimension. Appropriate methods included ultrasound follicle measurement, along with validated hormonal assays (FSH, LH, estradiol, progesterone, inhibin, prostaglandins). There were no geographical limits or publication-year limits.

RESEARCH METHODS

This is a narrative review that stems from a focused, but not systematic, literature search regarding follicular dynamics and hormonal control in cyclic mares. The major databases searched were PubMed, Scopus, Web of Science and Science Direct with additional or recently published literature retrieved from Google Scholar searches. These included species and topic related terms like “mare,” “equine,” “horse” and “ovary,” “follicle,” “follicular dynamics,” and “follicular wave,” as well as “preovulatory follicle,” “estrus/estrus cycle,” and hormone related terms such as “FSH,” “LH,” “estradiol,” “progesterone,” “inhibin,” and “prostaglandin.” Studies published between 1990 and 2026 were searched first to include recent ultrasonographic and endocrine research, but older, seminal work was also included, when it was available, and provided fundamental information on equine reproductive physiology. In addition to the databases searches, some frequently cited primary articles (such as Ginther and colleagues, Donadeu and co-workers or other significant authors of the field) have also been hand-searched for additional relevant articles that might not be identified by keyword literature searches. Books and book chapters that summarized and made sense of primary research findings in equine reproductive physiology and stud management were also included.

Inclusion and exclusion considerations

Studies that documented temporal changes in ovarian follicular development (e.g., serial ultrasonography throughout the estrus cycle or breeding season) and/or temporal patterns of reproductive hormones in clinically normal, non-pregnant mares going through naturally occurring or seasonally appropriate cycles were included in this narrative review. Literature reviewed included publications that addressed one or more of the following areas: normal estrus cyclicity in the breeding season with subjects on follicular wave emergence, deviation, dominant follicle selection, preovulatory follicle development and ovulation, ultrasonographic or morphologic evaluation of follicular development, endocrine changes accompanying follicular waves and clinical or physiologic interpretation of the ovulatory events. Reports that satisfied the eligibility requirements were limited to peer-reviewed papers and crucial book chapters that summarized primary research, employed validated hormone assays and recognized imaging, and included enough methodological information to explain follicular and endocrine trends. Studies that only looked at induced or pharmacologically synchronized cycles, single time-point observations with no discernible temporal trends, non-equine research unless specifically used for comparative context, and conference abstracts, thesis, or other non-peer-reviewed materials that were not available in full text were all excluded.

Scope and number of sources

Applying the above criteria, a final body of evidence of about 40-50 primary research articles and key reviews was selected as the core body of evidence for this narrative synthesis. Titles and abstracts of approximately 120-150 articles were initially identified from above mentioned databases and were then screened informally to exclude obvious irrelevant studies (e.g. non-equine species, studies on stalls or irrelevant endocrine topics) leaving around 60-70 articles to be examined more carefully for full text. Of those, studies that included detailed information regarding the follicular wave patterns, preovulatory follicle dynamics, and related endocrine changes in the physiologic breeding season in mares were retained and cited throughout this manuscript. As the goal of this study was to offer an integrated, extensive overview, additional classic or highly influential papers that fell outside the original 1990 to 2026 window for this synthesis were purposefully included when they were judged to be important in understanding the evolution of the present concepts of equine follicular physiology.

RESULTS AND DISCUSSION

Follicular development

Follicular development in mares is a complex and dynamic process characterized by distinct patterns of growth and regression, with significant variations influenced by the estrus cycle phase, season, and individual factors. Growth of antral follicles in the ovary occurs in wave-like patterns and is influenced by several factors, including the stage of the estrus cycle, season, pregnancy, age, breed, and individual mare characteristics. Typically, 1 to 3 waves occur per cycle, with major waves leading to ovulatory follicles and minor waves to anovulatory follicles. Wave intervals average around 9-10 days, with follicle size and growth rates varying by wave type and physiological state, including seasonal and postpartum variations (Ginther, 1993; Ginther & Bergfelt, 1993; Ginther et al., 2004; Raz & Aharonson-Raz, 2012; Sirosis et al., 2010; Watson et al., 2002). Major waves produce one dominant follicle and several subordinate follicles, while mean maximum diameter of follicle of minor wave has been reported as 22 - 23 mm (Ginther, 1993; Ginther et al, 2004). However, the subsequent study stated minor waves consists of follicles not exceeding 30 mm in diameter which regress thereafter (Satué & Gardón, 2013). This difference may be due to differences in classification criteria and to the fact that it is difficult to definitively distinguish between delayed or non-ovulatory major waves and late regression of minor waves in clinical material.

During each estrus cycle, mares typically produce one or two major follicular waves. The terms primary and secondary major follicular waves have been used for the equine estrus cycle. The primary major wave usually occurs near mid-diestrus, gives origin to a dominant follicle that ovulates in the primary ovulation leading to ovulation at the end of estrus. A secondary major wave may emerge during late estrus or early diestrus (Satué & Gardón, 2013) which is seen in about 25% of Standardbreds, Thoroughbreds, Quarter horses, Brazilian Breton small draft horses (Ginther, 2017).

Major (ovulatory) waves can be divided into four phases: common growth, deviation or selection, dominance, and ovulation (Ginther, 1993; Cortés-Vidauri et al., 2018). The common growth phase typically extends from emergence of follicles that can be ultrasonically identified (6mm diameter) until deviation (phase where follicle is selected to continue growth as dominant follicle) which is characterized by preferential and continued growth of one and occasionally two follicles of the wave (Ginther, 1993; Ginther et al., 2004). Over the course of one to several days, an average of 7 to 11 follicles per wave emerge at diameters of 5 to 6 mm and go through a common-growth period that lasts roughly six days (Raz & Aharonson-Raz, 2012). Minor differences in reported wave numbers or emergence timing are mainly attributable to breed, individual variation, and ultrasound examination frequency (daily vs. less frequent). The common-growth phase provides a critical window during which the future dominant follicle gains its initial size advantage. Individual and breed variations in follicle numbers and wave patterns were also observed (Gastal et al., 2008). The fact that wave detection and characterization are impacted by variations in study populations (breed, season), ultrasonographic resolution, wave emergence definitions, and sampling intervals possibly explains the divergence in studies. Follicular patterns naturally change during transitional and anovulatory periods. It was observed that normal follicles were not larger than 10 mm (two largest follicles having diameter of 7.5 and 8 mm) on day 6 post ovulation (Driancourt et al., 1982). Follicular emergence, defined as the future dominant follicle reaching approximately 6 to 13 mm, occurred on average at day 8.1 ± 0.7, with a range from day 1 to day 14 after ovulation (Ginther et al., 2005).

Follicular waves in the mare are temporally preceded by a stimulatory surge in circulating follicle stimulating hormone (FSH) with no concomitant increase in luteinizing hormone (LH) (Ginther, 1993; Ginther et al., 2004). During this phase, the growth rate of follicles is uniform (2.8 mm per day), and none of the follicles influences the growth of other follicles (Gastal et al., 1997) as all follicles have the ability to continue their growth and participate in the next phase of follicular development with the stimulatory effect of FSH. The wave-associated FSH surge reaches a peak when the largest follicle is approximately 13 mm in diameter (Donadeu & Ginther, 2001; Gastal et al. 1997) which happens 3 days before the expected date of deviation (Bergfeld et al., 2001; Ginther et al., 2003; Ginther et al., 2005). FSH concentration on the day before expected deviation were reported to be significantly greater in mares with one or two growing follicles compared to those with three or more follicles (Ginther et al., 2005) which clarifies that negative correlation is established between FSH concentration with the number of growing follicles. This phenomenon occurs because the greater the number of growing follicles the higher is the concentration of inhibin in the bloodstream which intentionally starve the system of FSH to restrict the growth subordinate follicles.

Table 1. Comparative summary of follicular wave characteristics in mare

Parameter	Commonly reported finding	Source of variation among studies	Clinical interpretation
Number of major waves per cycle	Usually one or two major waves per cycle. (Jacob et al., 2009; Sirois et al., 2010)	Breed, season, and frequency of monitoring.	A single scan may not accurately identify which wave will become ovulatory.
Minor-wave follicle diameter	Often 22–23 mm, (Gastal et al., 1999; Ginther 1993; Ginther et al., 2004; Jacob et al., 2009) but some reviews cite up to 30 mm before regression (Satué & Gardón, 2013).	Different wave classification criteria and study populations.	Minor waves should be interpreted cautiously in mares with irregular follicular turnover.
Follicle emergence	Usually detected when follicles are 5–6 mm (Ginther, 1993; Ginther et al., 2004; Raz & Aharonson-Raz, 2012), though some studies use 6–13 mm for the future dominant follicle (Driancourt et al., 1982; Ginther et al., 2005).	Different operational definitions of "emergence."	Timing of emergence depends on how the study defines the starting point.
Number of recruited follicles	Roughly 7–11 follicles per wave (Raz & Aharonson-Raz, 2012).	Ultrasonographic sensitivity, breed, age, and cycle stage.	Cohort size should be viewed as a range, not a fixed diagnostic criterion.
Growth during common-growth phase	Approximately 2.8 mm/day (Gastal et al., 1997).	Measurement interval, follicle chosen for analysis, and season.	Serial monitoring is more informative than relying on single-day growth assumptions.

Follicular deviation/selection and dominance

While the emergence of a wave is initiated by a surge in FSH, its subsequent progression is governed by a complex interplay of endocrine and paracrine factors that ensure the selection of a dominant follicle. As the recruited follicles grow, they produce estrogen and the peptide hormone inhibin which exerts a strong negative feedback on the pituitary to suppress FSH secretion.

During selection of a follicle for dominance, one of the primary actions of FSH is to induce the expression of LH receptors on the surface of granulosa cells in addition to the FSH receptors they already possess. This acquisition is the single most important event that allows the future dominant follicle to thrive while other fail. In the face of declining FSH levels, the subordinate follicles, which were solely FSH dependent, starve and undergo atresia. The selected future dominant follicle is now responsive to both FSH and LH. The declining blood concentration of FSH are sufficient enough to promote the growth of the largest follicle up to 48 hours after the expected diameter of deviation (22-23 mm) (Gastal et al., 1999; Ginther et al., 2003; Ginther et al., 2004; Jacob et al., 2009). The largest follicle continues its rapid growth at a rate of 2.3mm per day (Satué & Gardón, 2013) and massive estrogen production even with low FSH level as it can then respond to the basal LH levels that is always present. This differential response shown by the largest follicle and subordinate follicles results in initiation of diameter deviation (22.5mm vs 19mm) thus helping in selection for dominant follicle. Consequently, up to deviation, the FSH promotes follicular growth then after LH is responsible for encouraging the development of dominant follicle (Bergfelt et al., 2001; Gastal et al., 1997).

The following decline in FSH results from an increase in circulating inhibin, presumably inhibin-A (Medan et al., 2004; Watson et al., 2002), attributable to production of high levels of inhibin and estradiol by the dominant follicle (Donadeu & Ginther, 2001, 2002; Gastal et al., 1999). This process is further modulated by local factors within the ovary. Insulin-like Growth Factors (IGFs), particularly IGF-1, promotes granulosa cell proliferation and act synergistically with gonadotropins to promote follicular cell differentiation (El-Maaty & Abdelnaby, 2017; Medan et al., 2004; Spicer & Echternkamp, 1995). Before the commencement of deviation, the future dominant follicle's concentration of free IGF-I rises distinctly (Donadeu & Ginther, 2002). Estradiol enhances the production of IGF-I and boosts the expression of gonadotropin receptors in the granulosa cell thereby making granulosa cells more sensitive to gonadotropins.

Several studies emphasize a role for insulin-like growth factor-1 (IGF-1) in supporting follicular selection, particularly through enhancement of granulosa cell proliferation and increased sensitivity to gonadotropins. However, the magnitude of IGF-related effects differs among reports, likely because free intrafollicular IGF-1 is more difficult to characterize consistently than systemic endocrine variables and may be influenced by season, follicular fluid sampling strategy, and assay methodology. Likewise, reports on inhibin and estradiol patterns during deviation are generally aligned in direction but not always in absolute magnitude. This likely reflects biological variation among mares, differences in sampling intervals around deviation, and whether the study was performed in naturally cycling mares or under experimental endocrine manipulation.

During this stage, the literature's comparative significance becomes more apparent. While decreased FSH, rising estradiol, increased inhibin, and acquisition of luteinizing hormone (LH) responsiveness by the eventual dominant follicle are all crucial to deviation, the proportional importance of each pathway varies among the major findings. While descriptive ultrasonographic investigations focus on the diameter divergence and regression of subordinate follicles, experimental endocrine studies often emphasize the significance of intrafollicular signaling and gonadotropin receptor dynamics. These differences do not necessarily indicate conflict; rather, they reflect the fact that deviation can be studied from structural, endocrine, or molecular perspectives. The apparent inconsistency across papers is therefore best interpreted as a consequence of differing endpoints rather than disagreement about the biologic sequence itself.

According to the published information the second-largest follicle has the capacity for dominance in most mares for at least 2 days after the beginning of deviation which was shown in 67% mares in which the largest follicle was ablated 1 or 2 days after the expected beginning of deviation (Ginther et al., 2004). This might be due to the fact that the level of FSH returns to its basal concentration only 2 to 3 days after the deviation (Checura et al., 2009).

Preovulatory follicle

The preovulatory follicle grows at an average rate of 3 mm/day from deviation, reaching ~35 mm in diameter four days pre-ovulation (Aurich, 2011; Donadeu & Pedersen, 2008). During dominance, LH's role intensifies, as ovulatory competence – the dominant follicle's maximal responsiveness to an LH surge – relies on circulating LH concentrations exceeding those required for dominant follicle growth (Donadeu & Watson, 2007).

Follicular growth continues until ~2 days pre-ovulation, plateauing at ~40 mm (Ginther et al., 2008). Maximum preovulatory follicle diameter generally ranges from 40-45 mm in breeds like Quarter Horse, Arabian, Thoroughbred, and Spanish Purebred, though diameters can extend to 30-70 mm. Smaller breeds or those below 350 kg typically exhibit smaller follicles (35-40 mm) (Satué & Gardón, 2013). For Arabian mares, the average size was 46.3±4.34 mm (range 39-60 mm) (Çil et al., 2025). Follicle size also varies with breeding season and number of ovulations: follicles were found typically 8.5 mm larger in spring (vs. summer/autumn) and 4.9 mm smaller with multiple ovulations (vs. single) (Satué & Gardón, 2013). Diameter also varies between ovulatory cycles (second cycle smallest mean size), and parous mares have substantially larger follicles than maiden mares (Çil et al., 2025). These differences are plausibly explained by breed, body size, parity, season, number of ovulations, and repeated within-mare biologic consistency, and they should therefore be interpreted as physiologic variation rather than inconsistency alone.

Estradiol, secreted by the preovulatory follicle, peaks 1-2 days before ovulation (Medan et al., 2004; Tsukada et al., 2008), causing behavioral estrus signs and reproductive tract changes. Mares become sexually receptive, showing restlessness, stallion seeking, frequent urination, tail raising, squatting, and clitoral winking (Crowell-Davis, 2007). The vulva, vagina, and cervix exhibit congestion and edema; the cervix is open, relaxed, and produces fluid mucus. Endometrial estrus edema, appearing as a characteristic 'cart-wheel pattern' due to prominent folds, is easily identified with transrectal ultrasound. Histologically, this edema was found to be most evident in the stratum compactum and is often linked to small amounts of fluid in the uterine lumen (Raz & Aharonson-Raz, 2012).

Approximately 24-48 hours before ovulation, follicles may lose tone and cease growth. Preovulatory follicles, 12-24 hours prior to ovulation, undergo pronounced morphological changes, transitioning from spherical to non-spherical (Gastal et al., 1998) and often becoming pear-shaped or conical in 84% of mares (Kimura et al., 2005; Satué & Gardón, 2013).

Moreover, comparative synthesis reveals that apparent differences in timing and hormonal emphasis largely stem from methodological heterogeneity (daily vs. intermittent ultrasonography, assay specificity for inhibin isoforms, spontaneous vs. induced cycles) and biological factors (breed size, age, parity, and season within the breeding period).

Table 2. Comparative summary of preovulatory follicle characteristics

Parameter	Commonly reported observation	Likely explanation for variation	Practical relevance
Growth after deviation	Diameter deviation begins at 20-23.9 mm follicle size (Donadeu & Ginther, 2002), growth about 2.3–3.0 mm/day (Aurich, 2011).	Breed, season, monitoring interval, and whether growth is averaged or measured near ovulation.	Daily growth rate should support, not replace, serial reproductive examination.
Diameter four days before ovulation	Approximately 35 mm (Aurich, 2011).	Mare size, parity, season, and follicular history.	Useful as a trend marker rather than an absolute threshold.
Maximum preovulatory diameter	Commonly 40–45 mm, but wider ranges are reported (Çil et al., 2025; Ginther et al., 2008; Satué & Gardón, 2013).	Breed differences, body weight, single versus double ovulation, season.	Ovulation may occur outside the “typical” size range in normal mares.
Follicular shape before ovulation	Spherical to non-spherical, pear-shaped, or conical (Gastal et al., 1998; Kimura et al., 2005; Satué & Gardón, 2013).	Scan timing and image interpretation differences.	Shape change can improve prediction when interpreted with edema and estrus behavior.
Estradiol-related signs	Estrus behavior and uterine edema increase before ovulation (Cortés-Vidauri et al., 2018; Crowell-Davis, 2007).	Individual behavioral variation and examination timing.	Behavioral and ultrasonographic findings should be integrated together.

Ovulation

Mares ovulate 24-48 hours before the end of estrus (typically 4 p.m. - 8 a.m.). Follicle size at ovulation averages 45 mm (Hughes et al., 1977), ranging 35-55 mm (Ginther, 1993; Ginther & Bergfelt, 1993). While preovulatory follicles can exceed 55 mm, mares consistently ovulate from similar diameters in consecutive cycles (Cuervo-Arango & Newcombe, 2008). The mare ovary is distinguished from other domestic species by an ovulation fossa, an inverted corticomedullary arrangement, and its large size (35–120 cm^3 volume; 40–80 g weight) (Kimura et al., 2005). The follicle migrates to this fossa, the sole site of oocyte release. Ovulation, the rupture of the follicular wall, releases the oocyte and follicular fluid into the fossa. The ovulatory LH pulse activates matrix metalloproteinases–proteolytic enzymes responsible for tissue remodeling–leading to follicular rupture.

As estradiol declines before ovulation, luteolysis causes a reduction in progesterone. This reduced progesterone negative feedback on the hypothalamus increases GnRH release, promoting LH secretion crucial for ovulation (Cortés-Vidauri et al., 2018; Gastal et al., 1999; Ginther et al., 2006). LH levels gradually increase as ovulation approaches, peaking two days after estradiol. The preovulatory LH surge, triggered by estradiol, is essential for ovulation. LH secretion persists for 6–7 days in mares (Ginther et al., 2004), with a substantial increase observed from 48 hours before to one day after ovulation, peaking the day after (Ginther et al., 2005; Ginther et al., 2006; Cortés-Vidauri et al., 2018) which should be considered when interpreting endocrine timing in equine reproduction. About 40% of mares with two dominant follicles undergo double ovulation (24-hour interval), potentially leading to twin gestation

(Ginther et al., 2008). The reviewed literature also notes clinically relevant variation, including double ovulation, larger spring follicles, smaller follicles in multiple ovulations, and age-related prolongation of interovulatory intervals. These findings underscore that practical reproductive management should rely on serial examination and not on a single expected follicle diameter threshold for all mares.

Table 3. Comparative Timeline of Key Events in a Typical Major Follicular Wave During the Breeding Season in Mares. (Detail breakdown of the different phases of follicular development from wave emergence, common growth phase, deviation (~Day -7 relative to ovulation), dominance till ovulation)

Phase	Approximate Days (relative to Ovulation)	Largest Follicle Diameter	Key Hormonal Events	Clinical Notes
Wave Emergence	Day -10 to -8	5–13 mm	FSH surge	Cohort recruitment
Common Growth	Day -8 to -7	13–22 mm	FSH declining, inhibin/ estradiol rising	Uniform growth
Deviation / Selection	~Day -7	22–23 mm	IGF-1 ↑ in dominant, LH receptors ↑	Critical selection point
Dominance	Day -7 to -4	23–35 mm	Continued growth under basal FSH	Dominant pulls ahead
Preovulatory	Day -4 to -1	35–45 mm	Estradiol peak (Day -2), LH surge building	Uterine edema visible
Ovulation	Day 0	40–45 mm (plateau)	LH peak (+1 day)	Occurs 24–48 h before end of estrus

Source: Cortés-Vidauri et al. (2018); Donadeu and Pedersen (2008); Gastal et al. (1997, 1998, 1999); Ginther (1993); Ginther et al. (2003, 2004, 2005, 2006); Hughes et al. (1977); Jacob et al. (2009); Sirois et al. (2010)

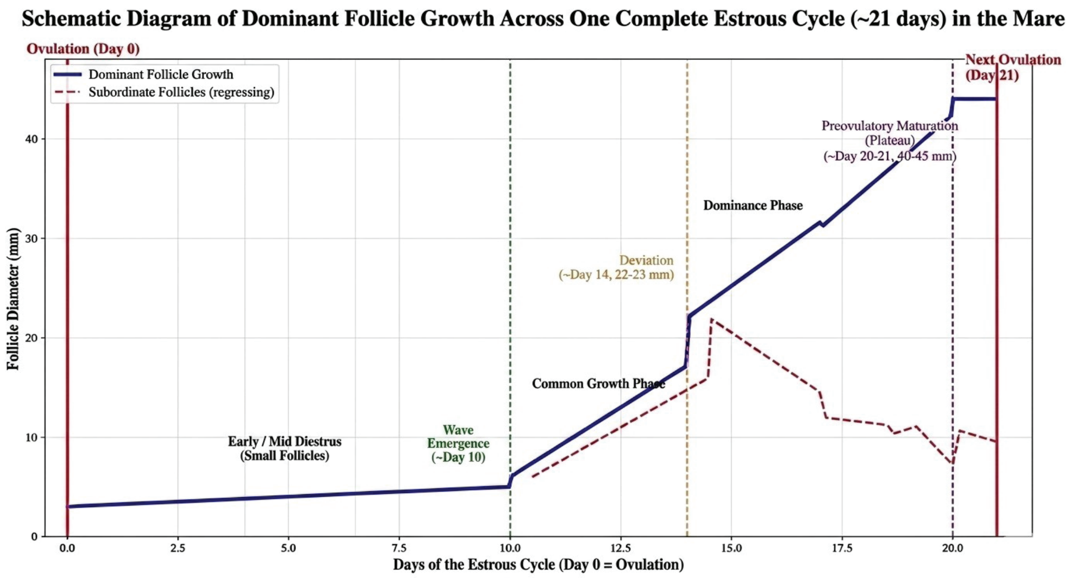

Fig. 1. Schematic diagram of dominant follicle growth across one complete estrus cycle (21 days) in the mare. The day of ovulation is represented by day 0. The main stages of a follicular wave are depicted in the diagram: emergence (~Day 10), common growth, deviation (~Day 14 at 22–23 mm), dominance, and preovulatory maturation, which results in the subsequent ovulation on Day 21. Depending on the breed, preovulatory follicle diameter usually reaches 40–45 mm.

Data sourced from Cortés-Vidauri et al. (2018); Donadeu and Pedersen (2008); Gastal et al. (1997, 1998, 1999); Ginther (1993); Ginther et al. (2003, 2004, 2005, 2006); Hughes et al. (1977); Jacob et al. (2009); Sirois et al. (2010).

Collectively, existing evidence supports a model where follicle selection in mares is governed by a dual system: a systemic endocrine component (FSH decline with basal LH) that shapes the overall environment, and a local intrafollicular component (IGF-1, inhibin-A, estradiol, receptor expression) that confers differential sensitivity on individual follicles within the wave (Donadeu & Pedersen, 2008; Gastal et al., 1997, 1998, 1999; Ginther, 1993; Ginther et al., 2004, 2005, 2006; Hughes et al., 1977; Jacob et al., 2009; Sirois et al., 2010). Nevertheless, important discrepancies remain, including variation in reported ultrasonographic datasets of follicular size at different stages. To address these discrepancies, a clear roadmap for future research should include well-characterized mare populations as well as large-scale ultrasonographic datasets across breeds and physiological states which would develop and validate uniform follicle-size thresholds for wave emergence and deviation, enabling reliable cross-study comparisons. Moreover, translational work linking a refined understanding of selection dynamics to practical protocols for timed insemination and ovulation induction should be studied which will eventually will help to reconcile divergent findings, sharpen the conceptual model of follicular selection, and improve the predictability of dominant follicle behavior in clinical equine reproduction. Similarly, divergence is seen in the diameter of the preovulatory follicle of mares in different breed and countries with different climatic conditions and no published information is found relating to reproductive functions and breeding status of horses in Nepalese context. As the follicular dynamics and effect of hormones on reproductive functions of mare are not well studied in Nepal, it is high time that Nepalese researchers should focus on the study and experiment of equine in Nepal.

CONCLUSION

In conclusion, systemic gonadotropins, ovarian steroids, and local intraovarian modulators interact in a highly coordinated manner to control follicular dynamics during the physiologic breeding season in the cycling mare. The physiological foundation for comprehending estrus behavior, ovulatory timing, and fertility control in equine treatment is provided by the transition from wave emergence to deviation, dominance, preovulatory maturation, and ovulation. A thorough understanding of these dynamic interactions between follicular growth and endocrine regulation provides a physiological basis for refining reproductive management strategies, including the timing of breeding or insemination, the use of hormonal protocols for cycle control and ovulation induction, and the interpretation of ultrasonographic findings in both fertile and sub-fertile mares, thereby contributing to improved fertility outcomes and more rational theriogenologic decision-making in equine practice. The main practical takeaway is that follicular development pattern, uterine edema, behavioral estrus, seasonal status, and mare-specific history should all be considered when making reproductive decisions rather than relying just on follicular size to forecast ovulation. Standardizing definitions of deviation and preovulatory endpoints, elucidating variation related to breed and age, and extending research into local ovarian signaling pathways that might account for variations in follicular competence and ovulatory efficiency among mares should be the main goals of future studies.

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CONFLICT OF INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

ETHICAL APPROVAL AND PERMITS

Not applicable.

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