



# Seasonal Reproductive Patterns, Estrus Behavior, and Ovarian Dynamics in Arabian Mares

Rami Ihsan Al-Timimi, Talib Musa Abdullah, Nazih Wayes Zaid

<sup>1</sup>Department of Surgery and Obstetrics-College of Veterinary Medicine-University of Baghdad. Baghdad. Iraq.

## Article Information

Received: 13-2-2026

Accepted: 19-2-2026

Published: 1-4-2026

## Abstract

Seasonality is a major determinant of reproductive efficiency in mares and can complicate breeding management during transitional periods. This study characterized seasonal reproductive patterns, estrus behavior, and ovarian dynamics in Arabian mares maintained under natural photoperiod in Baghdad, Iraq. Ten clinically healthy mares (5-15 years;  $9 \pm 3$  years) were monitored for 12 months. Estrus was detected by daily teasing and recorded using a standardized semi-quantitative scoring system. Rectal examination and transrectal ultrasonography (7.5 MHz) were performed at 15-day intervals (10-day intervals in irregular/prolonged estrus) to evaluate ovarian activity and confirm ovulation. Mares were classified as true polyestrus (Group A, n=6) or seasonal polyestrus (Group B, n=4) according to winter ovarian activity. Group B mares exhibited spring transition (March-May), a summer breeding season (June-August), autumn transition (September-November), and deep winter anestrus (December-February). Estrus intensity varied among individuals but generally escalated to peak receptivity (+++). Preovulatory follicles typically reached approximately 3-4 cm, and ovulation occurred 24-48 hr before the end of the follicular phase (estrus). Ovulation occurred slightly more frequently from the left ovary (53.6%) than the right (46.4%). These benchmarks provide practical field indicators for reproductive management of Arabian mares under Iraqi conditions.

**Keywords:** mare; seasonality; behavior; follicle; ovulation; ultrasonography.

## Introduction

Mares are long-day breeders in which photoperiod modulates hypothalamic-pituitary-gonadal activity, resulting in seasonal patterns of ovarian cyclicity. Many mares go into anestrus in the winter, then

transition to spring, then have a breeding season, and finally transition to fall (autumn transitional period). The degree of seasonal suppression varies and some mares stay in a cycle throughout the year. Seasonal changes impact estrus expression, follicular development and ovulation; thereby influencing reproductive efficiency and breeding management (Ginther, 1992; Nagy et al., 2000; Aurich, 2011).

Typical estrus behaviors include receptivity to a stallion, tail elevation, frequent urination and vulvar winking; conversely, diestrus is associated with rejection behaviors. The evaluation of estrus behavior is most dependable when combined with clinical examination and transrectal ultrasonography, particularly during transitional phases characterized by extended estrus and irregular ovulation (Ginther, 1998; Samper, 2009; McKinnon et al., 2011).

The objectives of this study were to: (i) describe seasonal reproductive patterns in Arabian mares, (ii) characterize estrus behavior and intensity of heat, and (iii) establish practical ovarian dynamic including follicle size and ovulation timing.

## **Materials and Methods**

### **2.1. Animals and Management:**

Ten healthy Arabian mares, aged between 5 and 15 years (mean age:  $9 \pm 3$  years) with no history of reproductive disorders, were used in this study. The mares were housed at Al-Zawraa Park, Baghdad, Iraq, under natural daylight conditions throughout the study period. All mares were in good body condition and fed a diet consisting of hay and pasture access, with water available.

### **2.2. Estrus Detection:**

Mares were teased daily with a stallion that used either open or closed field method as described by Ginther, (1992) to detect estrus behavior. Estrus was determined based on the observation of characteristic behavioral and signs indicators includes tail raising, frequent urination, winking of vulva, and receptivity to the stallion. Mares are classified into two groups based on estrous cyclicity observed across the year: true polyestrous mares that continuous reproductive activity around the year (Group A) and seasonal polyestrous mares showed winter anestrus with transitional periods (Group B).

Estrus intensity was assessed using a semi-quantitative grading system: (+) low, (++) moderate, (+++) high, and (–) absence of estrus signs. Luteal-phase behavior was characterized by rejection responses (avoidance, kicking, tail switching and ear retraction).

### **2.3. Rectal Examination**

Rectal examinations were conducted with the mares securely restrained in a stock. For nervous mares, a nasal twitch was applied, and an assistant deviated the mare's tail to facilitate a smooth examination. The operator's arm was protected with a long, lubricated plastic gloves, and the hand was gently inserted into the rectum. A slow rotational movement of the arm combined with gentle forward pressure was used to advance the hand further into the rectum. Once fecal materials were evacuated, the genital organs were carefully evaluated for normal anatomical features and any signs of abnormality.

These rectal examinations were scheduled every 15 days to assess ovarian activity and uterine changes with more frequent evaluations every 10 days performed if estrus was prolonged.

### **2.4. Ultrasonography Examination**

Ultrasonographic examinations were performed using a 7.5 MHz probe inserted gently into the rectum. As in the rectal examination procedure, mares were restrained in a stock, and for nervous individuals, a

nasal twitch was employed along with assistance to control the tail. The operator's arm was protected with a long, lubricated plastic sleeve, and the hand was carefully introduced into the rectum. A slow, circular motion paired with modest forward pressure helped the hand with the probe progress further. After the feces had been removed, portable ultrasonography was used to check on the activity of the ovaries and alterations in the uterus. These tests were planned every 15 days, although mares that were in estrus for a long time had them more often, every 10 days.

## **2.5 Statistical analysis**

Data were analyzed using the Statistical Analysis System (SAS, 2018), version 9.4. The effects of group (Group A versus Group B) and season (summer, autumn, winter, and spring) on follicular size, follicular phase length, luteal phase length, and estrus cycle duration during both the follicular and luteal phases were evaluated using analysis of variance (Two-Way ANOVA). Multiple comparisons between means were performed with the Least Significant Difference (LSD) test. Differences were considered statistically significant at  $P \leq 0.05$ . All data are presented as means  $\pm$  standard deviation.

## **Results**

### **3.1. Seasonality**

Ten healthy mares were examined in this study; the results showed that 60% of mares were true polyestrus and continuous cycling with normal reproductive activity throughout the year (6 mares, referred to as Group A). While 40% of the mares were seasonal polyestrus and exhibited significant variations in reproductive activity throughout the year (4 mares, identified as Group B).

The mares in Group B displayed the subsequent seasonal pattern: during Spring (March to May) all mares underwent a transitional phase in March. Reproductive activity began in one mare in April and in two additional mares in May, signifying a staggered initiation of estrus cyclicity throughout the spring transition. During the summer months (June to August), all mares exhibited typical reproductive activity during the breeding season. During Autumn (September to November), all four mares showed full reproductive activity in September. A progressive change was noted, with two mares entering a transitional period in October and the other two in November. In the winter season (December to February), all mares in Group B underwent a significant anestrus phase (deep anestrus).

### **3.2. Estrus Behavior:**

To assess behavioral indicators of estrus, mares in this study were categorized into two subgroups: Group A, consisting of six mares with regular estrus cycles, and Group B, consisting of four mares with irregular estrus cycles. Behavioral assessments of estrus exhibited considerable variation among mares, reflecting changes in the type, intensity, frequency, and latency of responses to stallion stimuli (Tab. 1). In the follicular phase (estrus), mares consistently exhibited specific signs such as: (+) standing in a straddled position with an elevated tail; (++) clitoral eversion (winking of vulva) accompanied by urination; and (+++) moderate tail elevation with a distinctive posture.

In contrast, during the luteal phase (diestrus), mares exhibited active rejection of the stallion through behaviors including kicking, tail switching, avoidance, and pinning their ears back, generally referred to as "active anestrus".

**Table 1: Intensity of estrus behavior in mares across consecutive days.**

No. Mare	Days of Heat							
	1	2	3	4	5	6	7	8
1	++	++	+++	+++	+++	-	-	-
2	++	++	++	+++	+++	++	++	-
3	+	++	++	++	+++	+++	+	-
4	+	++	+++	++	+	-	-	-
5	+	+	+++	+++	+++	+	+	-
6	++	++	+++	+++	+	-	-	-
7	+	+	++	+++	+++	+	-	-
8	+	++	+++	+++	+	-	-	-
9	+	++	+++	+++	++	++	-	-
10	++	+++	+++	+++	+++	+++	+	-

The intensity of behavioral indications exhibited by mares often escalated steadily during estrus, reaching its peak as ovulation neared. Furthermore, the presence of the stallion markedly affected the exhibition of estrus behavior in mares. Significantly, standard posturing behaviors linked to estrus were rarely exhibited in the absence of a stallion.

Mares in Group B displayed passive anestrus during winter, marked by a lack of acceptance and rejection behaviors towards the stallion. This passive anestrus results from a reduction in progesterone levels to baseline during the luteal phase in the anovulatory period.

The present study observed that during teasing sessions, stallions often exhibited the Flehmen reaction when mares were in estrus.

### 3.3. Estrus Cycle:

The results of this study indicated that mares in Group A exhibited stable reproductive parameters consistently throughout the year. Specifically, the duration of the follicular phase in Group A ranged between 5.61 and 6.50 days, while the luteal phase consistently averaged approximately 15 days, independent of seasonal variations (Tab. 2 and 3). Conversely, mares in Group B showed significant seasonal variations.

In detail, Group A exhibited follicular phase lengths during Summer, Autumn, Winter, and Spring of ( $5.72 \pm 0.16$  days), ( $6.22 \pm 0.23$  days), ( $6.50 \pm 0.15$  days), and ( $5.61 \pm 0.08$  days), respectively. In contrast, Group B had follicular phases lasting ( $5.84 \pm 0.11$  days) in Summer, markedly prolonged phases of ( $9.66 \pm 0.25$  days) in Autumn, (0.00 days) during Winter (anestrus), and significantly extended durations of ( $11.67 \pm 0.35$  days) in Spring.

**Table 2: Effect of Season on follicular phase length.**

Group	Mean $\pm$ SE (Follicular phase duration)			
	Summer	Autumn	Winter	Spring
<b>A</b>	5.72 $\pm$ 0.16 A a	6.22 $\pm$ 0.23 B a	6.50 $\pm$ 0.15 A a	5.61 $\pm$ 0.08 B a
<b>B</b>	5.84 $\pm$ 0.11 A c	9.66 $\pm$ 0.25 A b	0.00 $\pm$ 0.00 B d	11.67 $\pm$ 0.35 A a
<b>- L.S.D. = 1.162 *</b> <b>- Capital letters: Meaning significant differences between groups.</b> <b>- Small letters: Meaning significant differences within group.</b> <b>- * (P<math>\leq</math>0.05).</b>				

Statistical analysis revealed no significant seasonal differences in follicular phase length within Group A (P $\leq$ 0.05). While significant differences were noted in Group B, particularly favoring the extended follicular phases observed during Spring. Furthermore, a significant difference emerged when comparing the follicular phase lengths between Groups A and B (P $\leq$ 0.05).

Group B mares showed prolonged follicular phases during the transitional phases of Spring and Autumn (fall) characterized by irregular estrus signs without ovulation, ranging from 4 to 25 days with an average duration of 10.67 days. The follicular phase extended beyond 20 days especially in early to mid-April, marking the onset of the reproductive season for these mares. During winter, Group B mares entered deep anestrus and exhibited passive behavioral responses to teasing suggesting an inverse relationship between daylight length, ambient temperature and ovarian activity. The result observed during luteal phase in Group A mares consistently averaged approximately 15 days across all seasons. Group B mares exhibited notable increases in luteal phase duration during autumn (22.50  $\pm$  0.31 days) and spring (23.83  $\pm$  0.28 days), with no luteal activity recorded during winter (Tab. 3).

**Table 3: Effect of Season on luteal phase length.**

Group	Mean $\pm$ SE (Luteal phase duration)			
	Summer	Autumn	Winter	Spring
<b>A</b>	15.00 $\pm$ 0.27 A a	15.00 $\pm$ 0.24 B a	15.00 $\pm$ 0.24 A a	15.00 $\pm$ 0.26 B a
<b>B</b>	15.00 $\pm$ 0.22 A b	22.50 $\pm$ 0.31 A a	0.00 $\pm$ 0.00 B c	23.83 $\pm$ 0.28 A a
<b>- L.S.D. = 2.085 *</b> <b>- Capital letters: Meaning significant differences between groups.</b> <b>- Small letters: Meaning significant differences within group.</b> <b>- * (P<math>\leq</math>0.05).</b>				

The results of this study revealed no significant seasonal variation ( $P \leq 0.05$ ) in luteal phase length within Group A. For Group B mares, significant differences were observed in luteal phase length across seasons, particularly during spring and autumn, with an absence of luteal activity during winter ( $P \leq 0.05$ ).

Table 4 summarize the seasonal effect on the duration of the estrus cycle in two groups of mares (Group A and Group B). The results demonstrate that the duration of the estrous cycle fluctuated according to season. In Group A, the cycle durations recorded were ( $20.72 \pm 0.35$  days) in summer, ( $21.22 \pm 0.19$  days) in autumn, ( $21.50 \pm 0.34$  days) in winter and ( $20.61 \pm 0.20$  days) in spring. These results indicate minimal seasonal variation. In contrast, Group B exhibited marked seasonal variation. The estrous cycle duration was ( $20.84 \pm 0.26$  days) in summer, ( $22.50 \pm 0.41$  days) in autumn, ( $0.917 \pm 0.08$  days) in winter (reflecting deep anestrus), and ( $23.83 \pm 0.37$  days) in spring.

**Table 4: Effect of Season on Estrus Cycle Duration.**

Group	Mean $\pm$ SE (Estrus Cycle Duration)			
	Summer	Autumn	Winter	Spring
A	$20.72 \pm 0.35$ A a	$21.22 \pm 0.19$ A a	$21.50 \pm 0.34$ A a	$20.61 \pm 0.20$ B a
B	$20.84 \pm 0.26$ A b	$22.50 \pm 0.41$ A ab	$0.917 \pm 0.08$ B c	$23.83 \pm 0.37$ A a

- **L.S.D. = 2.659 \***  
- **Capital letters: Meaning significant differences between groups.**  
- **Small letters: Meaning significant differences within group.**  
- **\* ( $P \leq 0.05$ ).**

However, mares in Group B demonstrated significant differences ( $P \leq 0.05$ ) between summer, autumn, and spring when compared to winter, primarily due to seasonal variations in the lengths of the follicular and luteal phases.

### 3.4. Rectal Examination:

The results of the present study revealed robust ovarian follicular activity in mares, with preovulatory follicles reaching approximately 3-4 cm in diameter. Ovulation was observed to occur 24-48 hours prior to the end of the follicular phase.

Preovulatory follicle size, as measured via rectal palpation, increased progressively during follicular development and typically softened prior to ovulation. The frequency of ovulation from the left ovary was slightly higher than that of the right ovary; the difference was not significant. Specifically, 53.6% of ovulations occurred in the left ovary compared to 46.4% in the right ovary.

Uterine changes during the follicular phase included increased thickness of uterine horns, edema, and a toneless, heavier feel. During the luteal phase, developing follicles were generally absent from both ovaries, although one ovary often appeared slightly enlarged. The uterus exhibited a firm, tubular consistency.

In Group B mares, during transitional seasons (autumn and spring), the ovaries contained follicles about 2.0-2.5 cm in diameter, which were turgid and persistent. In contrast, during winter anestrus, the reproductive tract was generally quiescent. Rectal palpation revealed smooth, inactive ovaries and a firm.

### 3.5. Ultrasound Examination:

The findings of this study indicated a clear seasonal effect on follicle size as assessed via ultrasound (Tab. 5). In Group A, the mean sizes of preovulatory follicles were recorded as ( $33.25 \pm 0.65$  mm) in summer, ( $30.83 \pm 0.38$  mm) in autumn, ( $29.00 \pm 0.61$  mm) in winter, and ( $29.50 \pm 0.55$  mm) in spring. In contrast, Group B demonstrated notably reduced follicle sizes: ( $30.59 \pm 0.42$  mm) in summer, declining to ( $21.75 \pm 0.37$  mm) in autumn, with no observable follicular activity in winter ( $0.00 \pm 0.00$  mm), and measuring ( $20.50 \pm 0.28$  mm) in spring.

**Table 5: Effect of Season in Follicles size.**

Group	Mean $\pm$ SE (Follicles size mm)			
	Summer	Autumn	Winter	Spring
<b>A</b>	$33.25 \pm 0.65$ A a	$30.83 \pm 0.38$ A a	$29.00 \pm 0.61$ A b	$29.50 \pm 0.55$ A b
<b>B</b>	$30.59 \pm 0.42$ A a	$21.75 \pm 0.37$ B b	$0.00 \pm 0.00$ B c	$20.50 \pm 0.28$ B b
<p>- <b>L.S.D. = 3.016 *</b>  - <b>Capital letters: Meaning significant differences between groups.</b>  - <b>Small letters: Meaning significant differences within group.</b>  - <b>* (P<math>\leq</math>0.05).</b></p>				

These ultrasound findings confirm the effect of season on ovarian follicular development and maturation. Group A mare, there were significant differences observed between summer/autumn and winter/spring ( $P \leq 0.05$ ). As true polyestrous breeders, these mares exhibited relatively stable follicle sizes around the year, with only slight reductions from summer (33.25 mm) to winter (29.00 mm) and spring (29.50 mm). Group B mares characterized by seasonal polyestrous behavior and exhibited significant seasonal variation in follicle size with significantly reduced in autumn (21.75 mm) and spring (20.50 mm) compared to summer (30.59 mm), with no measurable follicular activity detected during winter ( $P \leq 0.05$ ). This absence signifies a pronounced state of anestrus, typical in seasonal breeders.

### Discussion:

The present study demonstrated clear individual variability in seasonal reproductive expression among Arabian mares maintained under natural photoperiod in Baghdad. Mares are classically as a long-day breeder; the depth of winter suppression and the duration of transitional periods differ among individuals and are influenced by photoperiodic sensitivity, nutritional status, temperature, and management practices (Ginther, 1992; Nagy et al., 2000; Aurich, 2011). In the current study, Group B mares showed deep winter anestrus (December-February) and two transition periods: spring (March-May) and autumn (September-November). This corresponds with the established yearly cycle of mare reproduction in temperate and subtropical environments (Palmer & Driancourt, 1983; Aurich, 2011).

Estrus detection via teasing remains a cornerstone in equine breeding management because it directly reflects receptivity and helps determine optimal timing for mating or insemination (McDonnell, 2000; Samper, 2009). The observed follicular phase behaviors, tail rise, frequent urination, winking of vulva, and receptivity to the stallion are consistent with classical descriptions of mare estrus and the estrogen-

driven behavioral phenotype (Crowell-Davis, 2007; McDonnell, 2000). While rejection responses of stallions recorded during the luteal phase (avoidance, kicking, tail switching, ear retraction) are due to progesterone dominance in diestrus and reduced sexual receptivity (Ginther, 1992; McDonnell, 2000). The semi-quantitative grading in this study provides a workable field tool; the individual variability in escalation patterns suggests that teasing alone may be insufficient during transition when estrus-like behavior can occur without ovulation (Ginther, 1992; Aurich, 2011).

The seasonal influences on cycle features seen in Group B, specifically extended follicular and luteal phases in spring and fall, are distinctive of the transitional phases in mares. During spring transition, mares repeated follicular waves with incomplete maturation, persistent medium follicles, irregular estrus expression, and failure of ovulation until the hypothalamic-pituitary axis becomes fully activated by increasing day length (Ginther, 1992; Donadeu & Ginther, 2002). The prolonged follicular phase and irregular estrus without ovulation observed in this study ranged from 4 to 25 days. It's due to physiologically reasonable and aligns with established transition physiology, indicating that LH production is inadequate for dominant follicle maturation and ovulatory competence during the early stages of transition (Nagy et al., 2000; Aurich, 2011). Similarly, extended luteal phases in transitional seasons may reflect altered luteolysis dynamics, persistent corpora lutea, or the presence of luteal tissue after irregular ovulations (McKinnon et al., 2011; Morel, 2015).

In the present study, rectal examination allowed consistent identification of follicular growth patterns, uterine tone variations, and seasonal ovarian inactivity, particularly in seasonal polyestrus mates of Group B during winter anestrus. These findings align with descriptions of equine reproductive physiology, in which ovarian size, follicular texture, and uterine tone reflect endocrine dominance (Ginther, 1992; McKinnon et al., 2011).

Pre-ovulatory follicles of approximately 3–4 cm (30–40 mm) were seen, according to the known ovulation criteria in mares. In the literature, it has been reported that ovulation takes place when dominant follicles are present between 35 and 45 mm (Ginther, 1998; Samper, 2009; Carnevale, 2008). Subtle follicular softening up to ovulation as seen in the current study has been ascribed to structural reorganization and an increased intrafollicular pressure that precedes follicle ruptures (Ginther, 1992; Stout, 2012). Ovulation was detected 24 - 48 h before the end of oestrus which is consistent with measurements known for peak estrus versus ovulation in mares (Samper, 2009; Morel, 2015). The ovulation rate of the left ovary (53.6%) was numerically greater than that of the right ovary (46.4%) but did not significantly differ. This is in accordance with previous studies which found that mares ovulate from both ovaries but with a slight but consistent lateral bias (Ginther, 1992; Carnevale, 2008). It seems that the seasonal variation identified in this study by rectal examination, was more marked in the seasonally polyestrus mares (Group B). At the time of transition, some medium-sized follicles (2.0–2.5 cm) persisted in size and ovulation did not take place. This is a feature of transitional physiology when follicles emerge repeatedly with inadequate support by luteinizing hormone (LH) and estrus activity occurs without ovulation (Donadeu & Ginther, 2002; Nagy et al., 2000; Aurich, 2011). Palpation of these small follicles >40 mm in the rectum during longer intervals of ultrasound, with the aid of transrectal US cleared marked this as a field pregnancy. At winter anestrus in Group B mares, the ovaries were smooth and inactive; the uterus firm and boardlike. This uterine tone might indicate lower, estrogen induced stimulation and endometrial edema in harmony with reduced gonadotropin and hormone activity under a short day regime (Aurich, 2011; Ginther, 1992). Lower uterine tone palpability in the follicular phase and higher tone values during the luteal phase would

also suggest a uterine firmness association with endocrine dominance given that progesterone stimulates myometrial tone and cervical closure (Noakes et al., 2019; Blanchard et al., 2003). Ultrasonic examination demonstrated that true polyestrous mares (Group A) maintained relatively consistent follicle size in the period of preovulation during each season, only slight decrease being shown in winter and spring. Seasonal polyesters mares (Group B), however, demonstrated clear seasonality suppression because of decreased follicular dimensions in autumn and spring and no development of follicles in winter. These results concur with the fact that ultrasonography can be used as an oestrus indicator for mares, and resemble previous findings showing that anestrus mares have small follicles and do not ovulate dominant follicles (Ginther, 1998; Newcombe, 2007). The persistence of 2.0–2.5 cm in group B during the transition period was also consistent with the transitional phenotype identified experimentally and in field studies where medium size follicles occurred frequently but did not always result in ovulation (Donadeu & Ginther, 2002; Stout, 2012).

### **Conclusion:**

This study demonstrates clear inter-individual variability in seasonal reproductive expression among Arabian mares maintained under natural Iraqi conditions. While true polyestrous mares maintained relatively stable estrus behavior, follicular development, and ovulatory activity throughout the year. Seasonal mares exhibited characteristic spring and autumn transitions and profound winter anestrus. Prolonged follicular phases, persistent transitional follicles, and suppressed winter ovarian activity highlight the physiological impact of photoperiod on reproductive dynamics. Rectal palpation and ultrasonography together provided reliable clinical benchmarks, including preovulatory follicle size (3-4 cm), ovulation timing within 24-48 hours of peak estrus, and seasonal uterine tone variations. These practical indicators are especially valuable for field-based breeding management.

### **References:**

- Aurich, C. Reproductive cycles of horses. *Animal Reproduction Science*. (2011); 124(3-4), 220-228. <https://doi.org/10.1016/j.anireprosci.2011.02.005>
- Brinsko, S. P., Blanchard, T., Varner, D., Schumacher, J. and Love, C. *Manual of Equine Reproduction*. (2011); 3<sup>rd</sup> edition, Mosby. <https://doi.org/10.1016/C2009-0-59988-6>
- Carnevale, E.M. The mare model for follicular maturation and reproductive aging in the woman. *Animal Reproduction Science*. (2008); 69(1), 23-30. <https://doi.org/10.1016/j.theriogenology.2007.09.011>
- Crowell-Davis, S. L. Sexual behavior of mares. *Hormones and Behavior*. (2007); 52(1),12-17. <https://doi.org/10.1016/j.yhbeh.2007.03.020>
- Donadeu, F.X., & Ginther, O.J. Follicular waves and circulating concentrations of gonadotrophins, inhibin and oestradiol during the anovulatory season in mares. *Reproduction*. (2002); 124(6), 875-885. <https://doi.org/10.1530/rep.0.1240875>
- Ginther, O.J. *Reproductive Biology of the Mare: Basic and Applied Aspects*. (1992); (2nd ed.). Equiservices Publishing.
- Ginther, O.J. *Ultrasonic Imaging and Animal Reproduction: Horses*. (1998); Equiservices.

- McDonnell, S.M. Reproductive behavior of stallions and mares: comparison of free-running and domestic in-hand breeding. *Anim Reprod Sci.* (2000); 211-209. [https://doi.org/10.1016/s0378-4320\(00\)00136-6](https://doi.org/10.1016/s0378-4320(00)00136-6)
- McKinnon, A.O., Squires, E.L., Vaala, W.E., & Varner, D.D. *Equine Reproduction.* (2011); (2nd ed.). Ames, IA: Wiley-Blackwell.
- Morel, M.C.G.D. *Equine Reproductive Physiology, Breeding and Stud Management.* (2015); (3rd ed.). CABI.
- Nagy, P., Guillaume, D., & Daels, P. Seasonality in mares. *Animal Reproduction Science.* (2000); 60-61, 245-262. [https://doi.org/10.1016/S0378-4320\(00\)00133-0](https://doi.org/10.1016/S0378-4320(00)00133-0)
- Newcombe, J. The Follicle: Practical Aspects of Follicle Control. *Current Therapy in Equine Reproduction.* (2007); 19, 14-21. <https://doi.org/10.1016/B978-0-7216-0252-3.50006-0>
- Noakes, D.E., Parkinson, T.J. & England, G.C.W. *Veterinary Reproduction and Obstetrics.* (2019); (10th ed.). Elsevier. DOI: 10.1016/C2014-0-04782-X
- Palmer, E. & Driancourt, M.A. Some interactions of season of foaling, photoperiod and ovarian activity in the equine. *Livestock Production Science.* (1983); 10(2),197-210. [https://doi.org/10.1016/0301-6226\(83\)90035-0](https://doi.org/10.1016/0301-6226(83)90035-0)
- Samper, J.C. *Equine Breeding Management and Artificial Insemination.* (2009); (2nd ed.). Elsevier.
- SAS. *Statistical Analysis System, User's Guide.* Statistical. (2018); Version 9.6th ed. SAS. Inst. Inc. Cary. N.C. USA.
- Stout, T.A.E. The dynamics of follicular development and ovulation in the mare. *Reproduction in Domestic Animals.* (2012); 47(Suppl 4), 6–13. <https://doi.org/10.1111/rda.12034>