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The Evaluation of Fertility Following Foal Heat or the Subsequent Postpartum Estrus in Purebred Arabian Mares

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ABSTRACT

Background: For high fertility in mares, it is important to have one foal a year and to have foaling early in the season, especially in racehorse breeders. Therefore, the fertility achieved by breeding the mare in foal heat is the determining factor. However, compared to thoroughbreds, there is not enough research on fertility results from postpartum breedings, such as foal and subsequent heats in Arabian mares. Thus this study aims to evaluate the fertility following the foal heat or subsequent postpartum breedings in Arabian mares.

Methods: In this study, in 184 mares (aged 4 to 25 yr), a total of 240 postpartum first breeding cycles (foal heat or subsequent heat), including 12 mares with three, 26 mares with two cycles and 152 mares had one cycle, were evaluated. The ultrasonograhic examinations were done to determine follicle diameter at the breeding day, pregnancy and pregnancy loss on days 14, 28 and 45 following breeding. In addition, live foal rates were also recorded. Mann-Whitney U and Chi-square tests were used to compare continuous and categorical data, respectively. The factors affecting breeding were analysed by logistic regression analysis and ROC analysis was used to calculate threshold values for the day of postpartum breeding and the follicle size at breeding.

Result: The per cent of mares were bred during their foal heat was 73%, while 27% were bred during their subsequent heat. The pregnancy rates for the mares bred at foal heat (56.8%, 100/176) and at subsequent heat (60.9%, 39/64) had no significant differences in between. Also, the pregnancy loss for the mares bred at foal heat and at subsequent heat were not significantly different, with 10.0% (10/100) and 2.6% (1/39), respectively. The live foal rate was also similar for the mares bred at foal (44.6%) and susequent heat (51.6%). It was found that the day of breeding (being earlier/at or later than 11 days pp) had significant effect on pregnancy (p=0.035) and pregnancy loss (p=0.025). In addition, live foal rates were effected by the day of breeding (p=0.017) and the size of the follicle (smaller or equal/greater than 47 mm) on the day of breeding (p=0.026). It was concluded that breeding a mare after the 10th day postpartum, along with a follicle diameter exceeding 47 mm on the day of breeding, has the potential to indicate achievable fertility for foal heat. Thus, it could be beneficial to taking these criteria into account in the postpartum reproductive management of Arabian mare.

Key words: Arabian mare, Fertility, Foal heat, Follicle size, Postpartum breeding.

INTRODUCTION

Arabian mares have an average gestation period of 342 days (Heck *et al*., 2017). In order for horse breeding to be considered productive, one offspring is targeted per year. For this purpose, it is expected that the mare will become pregnant again within 3 weeks after foaling. The absence of early pregnancy in the postpartum period causes the foaling dates to be gradually delayed in the following years. After all, due to the seasonality of the breeding behaviour, a year is skipped eventually for foal production (Bosh *et al*., 2009).

The first postpartum estrus (foal heat) begins 5 to 12 days following foaling and in most mares it results with ovulation within 20 days (Loy, 1980; Blanchard *et al*., 2004). Thus veterinarians or breeders prefer to breed mares early to get them pregnant at the beginning of the breeding season, except for mares who have problems during foaling (eg, dystocia, retention of fetal membranes, subinvolution, fever). Although the first postpartum estrus in mares is considered fertile (Ginther, 1992), there is controversy over the relative fertility achieved by early breeding of mares after foaling (Sharma *et al*., 2010; Scoggin, 2015). Many studies have reported lower conception rates (Merkt, 1966; Loy, 1980; Blanchard *et al*., 2004; Lane *et al*., 2016) and higher embryionic death rates (Bain, 1969; Malschitzky *et al*., 2015; Lane *et al*., 2016) in mares (without any

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pathological conditions) mated at the first postpartum heat. While some other studies (Camillo *et al*.,1997; Blanchard *et al*., 2004; Sharma *et al*., 2010), have reported similar conception rates and embryo losses when mares were mated in foal heat or later postpartum period. This information belongs more specifically to thoroughbred breeds. However, there are limited studies on reproductive performance of Arabian mares (Ali *et al*., 2014). Furthermore, there is no sufficient literature that presents fertility results from breedings conducted during early postpartum periods, such as foal and subsequent heats. Thus, the aim of this study was to evaluate the fertility following the first or subsequent postpartum breedings in Arabian mares.

MATERIALS AND METHODS

The study material consists of the reproductive outcomes of the first postpartum breeding practices for 240 cycles of 184 purebred Arabian mares. These mares were brought to a veterinary clinic offering stud services in Eskişehir Mahmudiye, located in the Central Anatolia Region, between 2020 and 2022. All mares were monitored from 7 days pp until the day of the confirmation of ovulation following breeding. The mares whose first postpartum breeding either at foal or subsequent heat were included in the study. The criteria considered for breeding the mares during the subsequent estrus cycle instead of foal heat include dystocia, subinvolution, metritis, fever, breeding that does not result in ovulation and inadequate follicle size. All mares without a history of reproductive issues considered healthy and were examined 7 days post-foaling using rectal palpation and ultrasonography. During the examination, the condition of the ovaries, follicle size (≥35 mm) and uterine edema are evaluated to monitor the mare until the most suitable time for breeding. The mares deemed suitable for breeding by natural mating or inseminated with fresh or frozen semen. Ovulation was checked 48 hours after breeding using ultrasonography and if ovulation had not occurred, breeding was repeated as necessary. All the stallions were state-approved purebred Arabian stallions registered in the World Arabian Horse Organization. The pregnancy status of the mares were determined by ultrasonographic examination on day 14 after ovulation and pregnancy checks for pregnant ones were repeated on days 28 and 45. Pregnancy loss was recorded, if any of these checks showed that the pregnancy had been lost. The live foal rates were determined by monitoring the pregnant mares until they foaling.

All the general data belongs to the mares such as the age of the mare, the age at using for first breeding, the number of years used as a breeding stock, the number of offspring, the number of seasons without offspring, the number of years used in breeding, the date of last foaling, the live birth rate were recorded. To determine fertility following postpartum breedings, the postpartum breeding day (Day 0, day of foaling), the follicle diameter at breeding, type of breeding (whether with natural mating, fresh or frozen-thawed semen transfer), foal or subsequent heats and fertility results (pregnancy, pregnancy loss and live foal rates) were evaluated. All animal procedures were performed under the protocol approved by the Bursa Uludag University - Local Ethics Committee For Animal Experiments (Approval No. #2020-07/01).

Mann-Whitney U and Chi-square tests were used to compare continuous and categorical data, respectively. Factors affecting breeding were analysed by Logistic regression analysis and ROC analysis was used to calculate threshold values for the day of postpartum breeding and the follicle size at breeding.

RESULTS AND DISCUSSION

In this study, 73% of the mares were bred during their foal heat (n=176), while 27% were bred during their subsequent heat (n=64). Sharma *et al.* (2010) reported that much more higher foal heat rate with 93% in their study which included Thoroughbred mares, however, since our study includes Arabian mares, it was thought to be due to the intensive reproductive management in Thoroughbreds and potential breed differences not reported comprehensively in the literature. The descriptive and reproductive data of the mares in the postpartum first breeding are presented in Table 1. According to the data in our study, line with the similar studies, it was found postpartum breeding day ranged 7 to 92 days (Ali *et al*., 2014) and the breeding day of the mares on foal heat were ranged between 7 to 21 (Sharma *et al*., 2010) and average breeding day was 10 d pp as was reported in Cardona-Garcia *et al*. (2024).

General pregnancy rate

The pregnancy rate for all the mares regardless of their first or subsequent breeding was 57.9% (139/240). It was within the range of previously reported (Ali *et al*., 2014) study in which the end-of-season overall pregnancy rate ranges 50-90% for Arabian mares. However, it was found lower then in the studies (Tekin *et al*., 1991; Özdemir, 1998; Çilek, 2009) which the general pregnancy rate reported as between 66 and 88% in Arabian mares. This variaty in pregnancy rates may caused by differences in fertility of stallion and mares and different reproductive management practices (Ali *et al*., 2014) and different uterine health status (Virendra *et al*., 2022).

In a point of view of the pregnancy rate per cycle which is an important indicator of fertility, is reported to be higher in Arabian mares (Benhajali *et al*., 2010) compared to Thoroughbred mares (Brück *et al*., 1993). Since the pregnancy rates we obtained in our study (58%) can also be evaluated as pregnancy per cycle, it can be said that although the pregnancy per cycle can be considered low for Arabian mares which reported as 84% (Benhajali *et al*., 2010), it should be noted that the pregnancy rate per cycle obtained in this study is specific to postpartum first breedings not including all cycles during the season. This rate is

sufficient to approach the pregnancy per cycle rate in Thoroughbred mares with 64% (Bruck *et al*., 1993).

Pregnancy rates in foal or subsequent heats

The pregnancy rates in our study for the mares bred at foal heat and at subsequent heat were similar with 56.8% (100/176) and 60.9% (39/64), respectively. In earlier studies, it is reported that pregnancy rates following foal heat were less than 50% (Sullivan *et al*., 1975; Roberts, 1986), align with the report (Rahawy, 2012) with 31% in Arabian mares. However, in our study, the pregnancy rate during foal heat for the Arabian mares (56%), found to be higher compared to the previous studies, but slightly lower to the studies including Arabian mares, reported as 66% (Elmatwally *et al*., 2017) and 67% (Gündüz *et al*., 2008).

Pregnancy rates achieved at the foal heat were 10-20% lower than those obtained by first breeding at subsequent estrous periods (Liuex, 1980; Loy, 1980; Kurtz Filho *et al*., 1997; Warriach *et al*., 2014; Souza *et al*., 2020). In the most recent study (Souza *et al*., 2020), pregnancy rates in Thoroughbred mares were lower for those bred on foal heat compared to subsequent heat (52.6% vs. 63.7%, respectively). In our study, although similar pregnancy rates (first or subsequent breeding with the rates 57% and 61%, respectively) were achieved to those obtained by Souza *et al*. (2020), pregnancy rates at the subsequent breeding showed no difference compared to the foal heat breeding. This indifference might be due to low number of mares in this study.

This wide variation in pregnancy rates may have arisen because current reproductive management strategies do not recommend breeding of the mares experiencing problems peri- foaling process (such as dystocia, retention of fetal membranes, uterine diseaes) during foal heat (Morris and Allen, 2002).

Pregnancy loss and live foal rates

Pregnancy loss following first postpartum breedings in Arabian mares in this study was found 7.9 % (11/139) which was found similar with the study including also Arabian mares (Ali *et al*., 2014) as about 4-19%. The pregnancy loss was numerically lower in subsequent breedings (2.6%, 1/39) compared to the rates in breedings at foal heat (10.0%, 10/100), but there was no differences in between.

Live foal rate following first postpartum breedings was determined as 46% (111/239) which is lower than Çilek (2009) reported as 69%. Also in presented study, live foal rates for the mares bred at foal heat and at subsequent heat were found similar with 45% and 52%, respectively. The lower live foal rate determined in presented study was thought to be due to, unlike the mentioned study (Çilek, 2009), only includes first postpartum breedings.

Factors influence the fertility

In presented study, the factors had effect on fertility following pospartum first breedings in Arabian mares were determined as the day of breeding, the size of follicle at breeding, the type of breeding.

Table 1: The descriptive and reproductive data of the mares.

	Age of mare (year)	Age at first breeding (year)	Number of offspring	Follicle size at 7 d pp (mm)	Follicle size at breeding day (mm)	Postpartum First Breeding day
All cycles (n=240)	10.2±0.24 (4-25)	5.3±0.10 (3-14)	4.09±0.17 (0-14)	36.47±0.60 (n/a-55.00)	47.38±0.29 (36.60-64.50)	16.58±0.83 (7-92)
Bred						
at FH (n=176)	10.4±0.28 (4-25)	5.4±0.12 (3-14)	4.14±0.21 (0-14)	38.45±0.55 (25.0-55.0)	47.63±0.34 (39.0-64.5)	10.16±0.25 (7-21)
at SH (n=64)	9.7±0.42 (5-19)	5.0±0.14 (3-8)	3.94±0.30 (0-10)	33.68±1.48 (n/a-52.0)	46.70±0.59 (36.6-62.0)	34.20±1.68 (15-92)

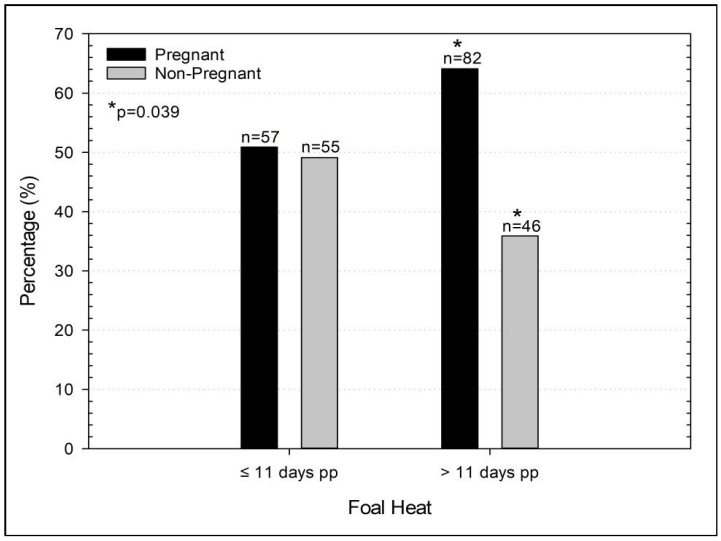
FH: Foal Heat; SH: Subsequent Heat, pp: Postpartum.

Even the age of the mare is one of the wellknown factors effect fertility, the age of the mare did not demonstrate a significant effect on pregnancy rates in presented study. Souza *et al*. (2020) noted that age has a considerable impact on fertility outcomes during the foal heat period. They indicated that in mares aged 10 years and older, used in breeding at subsequent heats is necessary to improve fertility and reduce embryonic loss rates. Since there is a high probability of postpartum problems in older mares (Troedsson, 1999; Frederiksson and Walter, 2013), the fact that mares with problems in foal heat management were not included in this study may have prevented the possible effect of age on fertility from being revealed.

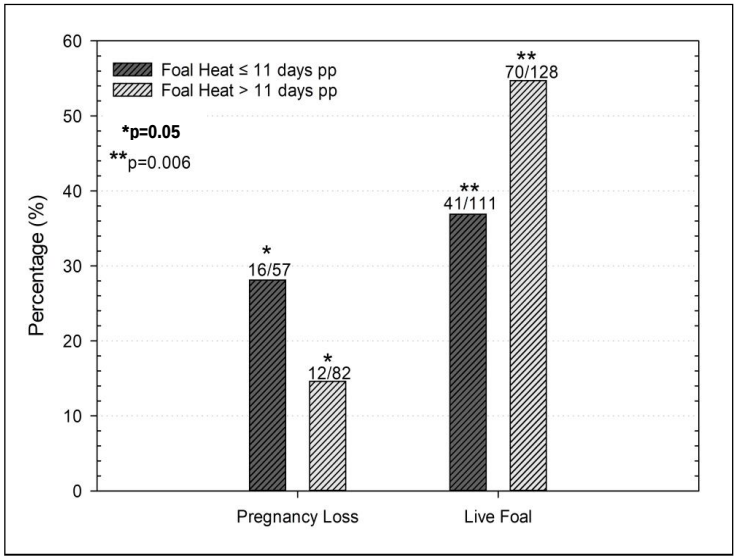
The day of postpartum breeding

Although the fertility obtained during foal heat was found to be satisfactory, it was determined that the fertility including pregnancy rate (p=0.035), pregnancy loss (p=0.025) and live foal (p=0.017) rates in mares bred before 11 days postpartum was significantly lower compared to those bred for the same purpose after this period in presented study. According to the pp breeding day, the pregnancy rate in the mares with their first pp breeding occurring before 11 days pp (50.9%; 57/112) was found to be lower (P=0.039) compared to the mares having their first pp breeding at 11 days or later postpartum (64.1%; 82/128) (Graph 1). A similar effect was also observed (Graph 2) in the mares having their breeding earlier or at/later than 11 days pp for both the pregnancy loss (P=0.05, 28.1%, 16/57; 14.6%; 12/82) and live foal rate (P=0.006, 36.9%, 41/111; 54.7%; 70/128), respectively.

Similarly, El wishy *et al.* (1990) reported that the mares were mated in foal heat earlier than 9-11 day resulted with lower pregnancy rate and, more noticably they reported



Graph 1: Pregnancies according to earlier or later than 11 days postpartum in Arabian mares.



Graph 2: Pregnancies according to earlier or later than 11 days postpartum in Arabian mares.

that abortions (4.3%) were limited to mares bred during the first 10 days after foaling. It has also been reported in another study (Ali *et al*., 2014), examined fertility from a different parameter expressed as pregnancy per cycle, that the average number of cycles per pregnancy tended to be higher in mares bred by day 9 after foaling than in those bred later. Similarly, Blanchard *et al*. (2004) attributed the low pregnancy rates observed in mares bred before postpartum day 10 to the uterine environment being unsuitable for pregnancy during the period until the embryo descends into the uterus. Therefore, it can be concluded that even under ideal conditions (problem-free foaling, standard-compliant uterine and follicular examinations for breeding decisions) which have been taken into consideration in our study, breedings conducted before the 10th day postpartum have a high likelihood of failure and breeding should be recommended in the subsequent cycle.

The follicle size

In our study, the range of preovulatory follicle diameters was determined to be between 34-64 mm, which is consistent with the follicle sizes reported by Ginther (2000; 35-58 mm). Indeed, the average preovulatory follicle diameter was found to be 47 mm (Table 1), aligning with the ideal follicle size of 45 mm as reported by Ginther *et al.* (2004).

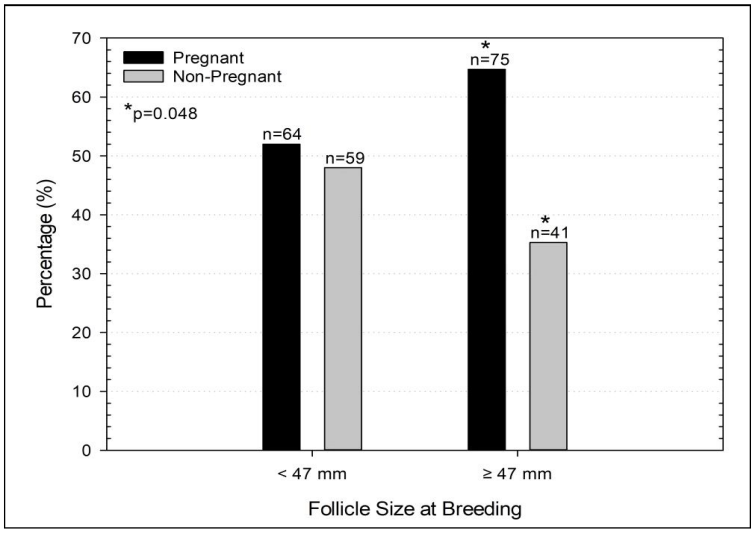
Also, it was determined that being the follicle size at breeding smaller or equal/greater than 47 mm have significant effects on the pregnancy (p=0.048) and live foal (p=0.026) rates but no effect on pregnancy loss (P= 0.502). According to the follicle size at breeding (Graph 3), the pregnancy rate in the mares with the follicle smaller than 47 mm at breeding (52.0%; 64/123) was found to be lower (P=0.048) compared to the mares with the follicle equal/larger than 47 mm (64.7%; 75/116). Similarly, the live foal rate in the mares with the follicle smaller than 47 mm at breeding (40.2%; 49/122) was found to be lower (P=0.040) compared to the mares with the follicle equal/larger than 47 mm (53.4%; 62/116).

Since, it was determined that mares with follicle larger than 47 mm had better fertility, it can be suggested that for the first postpartum breedings, the ideal follicle should be at least over 45 mm. Perhaps in Arabian mares, the follicle might need to grow slightly larger, since preovulatory follicle were reported lower in size with 43 mm for Thoroughbred mares (Benallou and Mellani, 2011), while Elmetwally *et al*. (2017) reported the preovulatory follicle as up to 46 mm in also Arabian mares.

However, no discussion has been formed regarding the reason why the effect of follicle size at breeding on pregnancy loss rates could not be determined and it has been concluded that further research is needed to clarification.

The type of breeding: Natural mating / Artificial insemination (AI)

The present study, in which both natural mating and AI were used, while 60% of the mares were bred with natural mating, 44% of the mares insaminated with either fresh semen (30%) or frozen-thawed semen (14%) and it was found that natural mating had more advantageous with increases pregnancy by 3.4 times (OR*=1/0.289=3.46; p=0.038). Indeed, when it comes to sperm cryopreservation in stallions, it has been reported that sperm can be damaged during the freezing and thawing stages (Kumar *et al*., 2011) and the use of different extenders can affect the sperma survival parameters (Tejpal *et al*., 2016; Shitikova *et al*., 2024) which can also effect on reproduction in different ways. Also, Ali *et al*. (2014) reported that natural mating is most preferred insemination type (77%), even they didn't find any effect on pregnancy. Lebedeva *et al*. (2021) reported that natural mating and AI with frozen semen at the foal heat in mares are advisable and can provide the normal pregnancy rate if a qualified control of the genital tract condition is ensured after foaling.



Graph 3: Pregnancies according to follicle size at breeding larger or smaller than 47 mm in Arabian mares.

CONCLUSION

It has been concluded that insemination during the foal heat in Arabian mares that have experienced an uncomplicated foaling process may yield satisfactory results. In addition, breeding a mare after the 10th day postpartum, along with a follicle exceeding 47 mm on the day of breeding, has the potential to indicate achievable fertility for foal heat. Thus, it could be beneficial to taking these criteria into account in the postpartum reproductive management of Arabian mares.

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Disclaimers

The views and conclusions expressed in this article are solely those of the authors and do not necessarily represent the views of their affiliated institutions. The authors are responsible for the accuracy and completeness of the information provided, but do not accept any liability for any direct or indirect losses resulting from the use of this content.

Informed consent

All animal procedures for experiments were approved by the Bursa Uludag University - Local Ethics Committee For Animal Experiments (Approval No. #2020-07/01).

Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this article. No funding or sponsorship influenced the design of the study, data collection, analysis, decision to publish, or preparation of the manuscript.

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