International Journal of Advanced Biochemistry Research

ISSN Print: 2617-4693
ISSN Online: 2617-4707
NAAS Rating (2025): 5.29
IJABR 2025; 9(8): 775-777
www.biochemjournal.com
Received: 19-06-2025
Accepted: 21-07-2025

Shantha Vardhan M
Ph.D Scholar, Department of Veterinary Gynaecology and Obstetrics, Veterinary College Hebbal, Bengaluru, KVAFSU, Karnataka, India

Renukaradhya GJ
Associate Professor, Department of Veterinary Gynaecology and Obstetrics, Veterinary College Hebbal, Bengaluru, KVAFSU, Karnataka, India

Sudha G
Professor and Head, Department of Veterinary Gynaecology and Obstetrics, Veterinary College Hebbal, Bengaluru, KVAFSU, Karnataka, India

Suchitra BR
Assistant Professor, Department of Veterinary Gynaecology and Obstetrics, Veterinary College Hebbal, Bengaluru, KVAFSU, Karnataka, India

Naveen Kumar S
Professor and Head, Department of Animal Genetics and Breeding, Veterinary College Hassan, Hassan, KVAFSU, Karnataka, India

Srinivasa Murthy KM
Associate Professor, Department of Veterinary Surgery and Radiology, Veterinary College Hebbal, Bengaluru, KVAFSU, Karnataka, India

Corresponding Author:
Shantha Vardhan M
Ph.D Scholar, Department of Veterinary Gynaecology and Obstetrics, Veterinary College Hebbal, Bengaluru, KVAFSU, Karnataka, India

A five-year retrospective study on reproductive performance and foal heat breeding outcomes in thoroughbred Mares stud farm under a subtropical climate

Shantha Vardhan M, Renukaradhya GJ, Sudha G, Suchitra BR, Naveen Kumar S and Srinivasa Murthy KM

DOI: https://www.doi.org/10.33545/26174693.2025.v9.i8j.5314

Abstract
This five-year retrospective study (2015-2019) evaluated reproductive performance parameters in 415 Thoroughbred mares across five different age groups in a stud farm in India. Data recorded on age, parity, breeding cycles, conception rates, twin pregnancies, early embryonic death (EED), late fetal death (LFD) and foal heat (FH) breeding outcomes were analysed. A total of 706 breeding cycles resulted in 349 pregnancies, with an overall per-cycle conception rate of 49.43% and a seasonal conception rate of 92.05%. Age significantly influenced conception rates ($p < 0.05$), with younger mares (4-7 and 8-11 years) exhibiting higher fertility. FH breeding occurred in 20.96% of foaled mares, yielding a 52.63% conception rate but higher EFD (15.79%). Statistical analyses were done using chi-square and Fisher's exact tests revealed trends in age-related declines in reproductive efficiency. These findings underscore the importance of age-specific management strategies to optimize breeding outcomes in Thoroughbreds under tropical conditions.

Keywords: Thoroughbred mares, reproductive performance, foal heat, conception rate, early embryonic death, late fetal death

Introduction
The Thoroughbred horse industry in India relies mainly on efficient reproductive management to maintain annual foaling intervals and optimize genetic progress. Horses are seasonal polyestrous breeders, with reproductive activity influenced by photoperiod, nutrition, age and parity (Aurich, 2011; Mahmood *et al.*, 2024) [2, 11]. The estrous cycle averages 22 days, with estrus lasting 5-7 days and follicular dynamics involving one to two waves per cycle (Ginther, 2000; Derisoud *et al.*, 2022) [6, 5]. Foal heat (FH), the first postpartum estrus occurring 5-12 days after foaling, offers an opportunity for early rebreeding but is associated with variable fertility due to incomplete uterine involution and hormonal imbalances (Sharma *et al.*, 2010; Suchitra, 2019) [12, 13]. Persistent or post breeding-induced endometritis (PBE) remains a major cause of subfertility, characterized by delayed uterine clearance and intrauterine fluid accumulation (Canisso *et al.*, 2020; Katila and Ferreira-Dias, 2022) [3, 7]. Age and parity exacerbate susceptibility, with older multiparous mares showing higher rates of EED and LFD (Knowles, 2022; de Souza *et al.*, 2020) [8, 4]. Genetic studies trace modern Thoroughbred lineages to the DOM2 domestication event around 2200 BCE in the Pontic-Caspian steppe, influencing current breeding practices (Librado *et al.*, 2021; Anthony, 2007) [10, 1]. Despite extensive data, few long-term retrospective studies exist on Thoroughbred reproductive performance in subtropical climates. This study analyses five years of data (2015-2019) from a stud farm in India to assess age-related trends in conception rates, pregnancy losses and FH breeding outcomes, providing insights for improved management.

Materials and Methods
This retrospective study analysed breeding records from 415 Thoroughbred mares aged 4 to >20 years at a commercial stud farm in subtropical are of India (13.0232°N latitude and

77.0252°E longitude) from January 2015 to December 2019. Mares were grouped by age: 4-7 years (n = 76), 8-11 years (n = 136), 12-15 years (n = 106), 16-19 years (n = 82) and >20 years (n = 15). Records included parity, number of mares bred, cycles serviced, pregnancies confirmed by transrectal ultrasonography at day 14 post-breeding, twin rates, EED (loss <45 days), LFD (loss 45-150 days), gestational length and FH parameters (onset, duration, interval to ovulation and breeding outcomes). FH was defined as the first postpartum estrus (5-12 days post-foaling). Breeding involved natural mating during estrus, with ovulation induced using hCG or recombinant equine LH when needed (Sharma *et al.*, 2010; Derisoud *et al.*, 2024) [12, 5].

Reproductive Management

Mares were housed in paddocks with ad libitum water, forage and concentrates and monitored daily for estrus via teasing. Ultrasonography assessed follicular dynamics and uterine health. Post-breeding management included oxytocin and antibiotics for uterine clearance and management of infection, respectively in susceptible mares.

Statistical Analysis

Data were aggregated by year and age group. Conception rates (per cycle and seasonal), twin rates, EED and LFD rates were calculated as percentages. Service per conception was calculated as cycles serviced/pregnancies. Chi-square tests employed to assess the associations between age groups and categorical outcomes (conception, twins, losses). Fisher's exact test was used for small expected frequencies (<5). Post-hoc pairwise comparisons applied Bonferroni-Holm adjustments. Continuous variables (e.g., FH onset) were analysed via ANOVA. Significance at $p<0.05$. Analyses used SPSS software (version 4.3.1).

Results and Discussion

During the study period (2015-2019), 415 Thoroughbred mares were evaluated, of which 394 (94.94%) were bred, resulting in 706 breeding cycles and 349 confirmed pregnancies. The overall per-cycle conception rate was 49.43%, while the seasonal conception rate was 92.05%, with a mean service per conception of 2.02. These values are comparable to earlier reports in tropical and subtropical conditions, where per-cycle conception rates ranged from 45% to 55% and seasonal conception exceeded 85% (Aurich, 2011; Mahmood *et al.*, 2024) [2, 11]. The present findings confirm that under well-managed tropical stud farms, fertility outcomes are maintained at levels consistent with global Thoroughbred standards. Twin pregnancies were observed in 10.03% of conceptions, aligning with the reported range of 7-25% in Thoroughbreds (Ginther *et al.*, 2000) [6]. Age did not significantly influence twinning rates, possibly due to uniform use of ovulation induction and post-breeding monitoring. The rate of pregnancy losses showed an increasing trend with age. Early embryonic death (EED) occurred in 9.74% of pregnancies, whereas late fetal death (LFD) was 13.18%. These values are within reported global ranges but were significantly higher in mares over 12 years of age ($p<0.05$). The rise in pregnancy losses with advancing age is attributable to progressive endometrial degeneration, reduced uterine clearance and persistent breeding-induced endometritis (PBE) as documented in earlier studies (Canisso *et al.*, 2020; de Souza *et al.*, 2020) [3, 4].

Age-wise Fertility Trends

Age exerted a significant influence on conception rates. Younger mares (4-7 years) achieved the highest per-cycle conception (62.61%) and seasonal conception (97.22%), while mares above 20 years recorded the lowest fertility (per-cycle 37.04%, seasonal 76.92%). The chi-square analysis confirmed age as a significant factor (p = 0.002 for per-cycle conception; p = 0.015 for seasonal conception). These findings agree with the reports of Derisoud *et al.* (2022) [5] and Aurich (2011) [2], who observed sharp declines in conception beyond 12 years, linked to compromised ovarian activity and uterine health. The higher incidence of EED (30.00%) and LFD (20-25%) in mares over 12 years underscores the age-associated susceptibility to embryonic and fetal loss, corroborating earlier observations by Schoon *et al.* (1997) (Table No. 1).

Foal Heat (FH) Breeding Outcomes

Out of 278 foaled mares, 23.74% expressed foal heat (FH) and 16.91% were bred. The overall conception rate to FH was 51.06%, which, although lower than regular seasonal breeding, is still within acceptable limits. Younger mares (4-7 years) showed 100% conception at FH, whereas older mares (>15 years) exhibited delayed onset of estrus (8.5±0.6 days) and reduced fertility. Statistical analysis revealed significant age-related variation in FH onset (p = 0.032) and breeding percentage (p = 0.037). FH breeding was associated with a higher risk of reproductive losses. EED and LFD in FH-bred mares were 4.26% and 16.67%, respectively, compared to non-FH mares (EED: 9.52%, LFD: 12.84%). Although differences were not statistically significant, the trend indicates increased uterine vulnerability during early postpartum periods, as supported by Sharma *et al.* (2010) [12] and Suchitra (2019) [13]. The reduced FH expression rate in the current study (23.74%) compared to temperate climates (85-95%; Lane *et al.*, 2016) [9] is attributed to tropical photoperiodic influences, confirming seasonal modulation of mare fertility in equatorial regions (Mahmood *et al.*, 2024) [11] (Table No. 2).

Table 1: Age-wise Reproductive Parameters (2015-2019)

Parameter	4-7 years (n = 76)	8-11 years (n = 136)	12-15 years (n = 106)	16-19 years (n = 82	>20 years (n = 15)	Total	χ^2	p-value
Parity (Mean ± SE)	0.82±0.18	3.55±0.21	6.42±0.31	9.15±0.39	11.06±0.62	-	-	-
Mares bred (%)	95.39	96.32	94.34	89.02	86.67	94.94	3.45	0.486
Cycles serviced	115	227	198	139	27	706	-	-
Pregnancies (No.)	72	122	84	61	10	349	-	-
Conception rate (per cycle, %)	62.61	53.74	42.42	43.88	37.04	49.43	16.78	0.002*
Conception rate (seasonal, %)	97.22	95.90	87.00	85.25	76.92	92.05	12.34	0.015*
Twins (%)	12.50	8.20	11.90	13.11	10.00	10.03	1.89	0.757
EED (%)	4.17	7.38	17.86	9.84	30.00	9.74	15.67	0.003*
LFD (%)	5.56	11.48	20.24	24.59	10.00	13.18	14.56	0.006*

Table 2: Foal Heat Parameters by Age Group

Parameter	4-7 years	8-11 years	12-15 years	16-19 years	>20 years	Total	χ^2	p-value
Foaled mares (No.)	47	109	70	46	6	278	-	-
FH expressed (%)	17.02	22.02	31.43	19.57	16.67	23.74	4.56	0.335
Bred at FH (%)	4.26	20.18	24.29	10.87	16.67	16.91	10.23	0.037*
Conception to FH (%)	100.00	40.91	52.94	60.00	0.00	51.06	7.89	0.096
EED at FH (%)	0.00	9.09	5.88	0.00	0.00	4.26	2.34	0.673
LFD at FH (%)	0.00	13.64	23.53	20.00	0.00	16.67	3.12	0.537
FH onset (days, Mean ± SE)	6.6±0.7	8.0±0.5	7.7±0.4	8.5±0.6	8.0±0.0	7.8±0.4	-	0.032*

Conclusion

The present study reaffirms that mare age is the primary determinant of fertility efficiency in Thoroughbred breeding. Younger mares consistently demonstrated higher conception rates, lower pregnancy losses and superior FH breeding outcomes. Conversely, mares above 12 years showed progressive fertility decline due to PBE, endometrial fibrosis and impaired placental development. These findings are in consonance with global literature but provide region-specific validation for tropical conditions.

Acknowledgments

No conflict of interest.

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