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A RETROSPECTIVE STUDY ON FACTORS INFLUENCING THE REPRODUCTIVE PERFORMANCE OF BROODMARES

Muhammad Athar Chatha[1*], Nisar Ahmad[2], Muhammad Athar Abbas[3], Muhammad Saadullah[4], Jawaria Ali Khan[5]

[1*,2,3,4]Department of Livestock Management, University of Veterinary and Animal Sciences, Lahore
[5]Department of Clinical Medicine & Surgery, University of Veterinary and Animal Sciences, Lahore

***Corresponding Author:** Muhammad Athar Chatta
*Department of Livestock Management, University of Veterinary and Animal Sciences, Lahore
Email: 2019-PhD-2025@uvas.edu.pk, Contact Number**:** +92300-8116552

ABSTRACT
This study aimed to compare the reproductive performance of a database of 120 broodmares of three different breeds (Arabian, Percheron, and Thoroughbred) for the last ten years (2012-2022) under subtropical conditions of Pakistan. A survey form was developed to systematically record and analyze the various factors that influence reproductive outcomes, such as mare age, breed, and housing management practices (excellent, good, and fair), were analyzed. The Arabian mares showed significantly higher foal numbers (5.45), foal heat conceptions (2.40), and pregnancy rates (43.95) at foal heat ($p<0.05$) compared to other breeds. Housing management plays a vital role in the performance of broodmares. Excellent housing management showed significantly higher results than others. Higher foal production (5.89), foal heat conceptions (2.67), and a lower rate of dystocia (0.00%) were observed in excellent management. Percheron mares have better rates of normal foaling (85%) and good foal production (100%), whereas Arab mares have far higher end-season fertility (85%). In summary, superior management correlates with higher rates of normal foaling and enhanced end-season fertility, offering crucial insights for optimizing broodmare management in subtropical climates and bolstering equine breeding sustainability.

Keywords: Mares, housing management, Pakistan, Conception rate, Foal

Introduction
In Pakistan, horses, donkeys, and mules have significant cultural and economic significance. They are essential to many people's livelihoods because they provide jobs in various fields, including ownership, breeding, training, and caring. These animals are significant in various businesses, including tourism, riding, racing, and recreational activities. A broodmare is a female horse that is used for breeding purposes, specifically for producing foals. These mares are chosen for their pedigree, conformation, and other desirable traits to pass on to their offspring. The presence of broodmares in the equine industry is crucial for the continued growth and development of the horse population and as a foundation for breeding operations[2].
Numerous factors affect broodmares' productivity and reproductive success, but one crucial factor is the environment. Seasonal fluctuations must be considered, and foals' development must be constantly monitored in breeding activities[3]. Three distinct horse breeds, the Arabian, the Thoroughbred, and the

Percheron, have unique characteristics and show subtropical climate adaptation[4]. Management strategies and breeding plans for these unique horse breeds must be adjusted to meet their unique needs and features to ensure excellent performance and successful reproduction[5].Pakistan's subtropical climate gives unique challenges for broodmares, including heat stress during the country's hot summers and unpredictable monsoons. These environmental stressors, increasing the risk of illness and lowering fertility, may affect reproductive physiology. Breeding conditions, feed availability, and disease control are all affected by seasonal variations. Heat stress can interfere with estrus cycles and reduce the chances of conception, thus it is important to understand the complex anatomy of the reproductive system. Effective cooling and management strategies are essential to address heat-related concerns, such as dehydration. Because of climate changes, breeding schedules must be carefully planned to avoid high heat stress [6, 7].

Many factors, including the season, year of birth, housing conditions, nutritional management, age at weaning, and foal sex, affect the growth and development of young horses. Optimizing the growth and well-being of young horses requires a thorough understanding of the effects of these variables. In Pakistan's subtropical environment, good management practices are essential to the well-being and reproductive success of broodmares. Ensuring adequate housing and shelter is essential[8]. Broodmares need animal care and healthcare examinations to make sure that their health is good. It is significant to take preventive measures against common subtropical diseases and disease-causing agents. Maintaining the best reproductive health for the broodmares includes regular care, deworming, and vaccinations[9].

There is limited available information on the reproductive performance of Arabian and Thoroughbred mares in subtropical nations[10]. Per-cycle pregnancy rates in Thoroughbred mares range from 54% to 64% [11] and in Arabian mares from 84% [12], according to retrospective research conducted worldwide. There are few reports of increased foaling rates, which could be attributed to higher selection standards and more rigorous mare care procedures [13]. Different countries have different rates of conception: Sweden [14], India [15], Australia [11], the UK [16], and India. However, as far as we are aware, there has been no scientific research conducted on the reproductive abilities of Arabian, Percheron, and Thoroughbred mares in Pakistan's subtropical climate.

The principal aim of this study is to thoroughly investigate and assess the impact of both extrinsic and intrinsic factors on the health, reproductive efficiency, and foal survival rates of broodmares across diverse breeds and management practices. Through a comprehensive analysis of these interactions, we strive to develop a nuanced understanding of the pivotal elements influencing the overall performance of broodmares, specifically within the subtropical conditions of Pakistan. This research seeks to contribute valuable insights aimed at enhancing the sustainability of equine breeding practices in subtropical regions, offering practical guidance to refine broodmare management effectively.

Materials and Methods

Location

The study investigated several stud farms located in Sargodha (32.1566° N, 72.8043° E), Faisalabad (31.4504° N, 73.1350° E) and Sahiwal (30.6490° N, 73.1350° E) Divisions of Pakistan.

Data collection

The study involved the analysis of a comprehensive database containing service records of 120 broodmares' reproductive performance for ten consecutive breeding seasons (2012–2022) with three different breeds, namely Thoroughbred, Arabian, and Percheron (40 each). A survey form was designed to record and analyze the housing, feeding, and management practices of the broodmares from breeding until weaning. Information and statistics about the performance of the broodmares were gathered. This includes information on foaling ease, foal survival, future breeding plans, and other ancillary details. Conception rate (CR) is the percentage of mares bred overall divided by the number of mares diagnosed as pregnant between 30 and 45 days post-ovulation. Comparing the number of mares bred or exposed to the stallion to the percentage of mares that conceive during the breeding

season is known as seasonal (or cumulative) CR. All broodmares were given numerical codes to protect the privacy of the farm.

Management practices

Ensuring a consistent approach to equine care, all study farms followed standardized housing management techniques with diligence. The mares' ideal living conditions were ensured by strict adherence to these established procedures, and the continual maintenance of housing facilities showed dedication to maintaining high standards of mare management.

Nutritional composition for broodmares

The recommended daily intake for brood mares carrying foals was 1.4 kg of grain, 1.8 kg of crushed barley, 1 kg of wheat bran, and 30 grams of salt. In addition, hay or green fodder was provided as needed. The purpose of this nutritional composition is to maintain the health and well-being of brood mares and their foals by meeting their unique dietary needs and providing a balanced and modified feeding program.

Housing management

The broodmares were categorized into three different housing management levels: excellent, good, and fair based on thorough assessments of stall space, pasture access, and general care. The categorization was designed to depict different levels of living circumstances impartially; "excellent" stood for superior facilities, roomy stalls, and outstanding care, "good" for acceptable conditions, and "fair" for basic accommodation with few facilities.

Reproductive disease assessments

Regular assessments for various reproductive diseases in all mares were conducted through speculum examination of the vaginal vault, as well as endometrial culture and cytology. The dataset for the current investigation effectively excluded mares having a history or indication of reproductive abnormalities, such as uterine infections, anatomical deformities, or repeat breeders.

Pregnancy detection

Three veterinarians evaluated ovarian follicular status and uterine edema using rectal palpation and ultrasonography. A known fertile stallion naturally mated with mares in estrus, and 48 hours later, re-breeding was ensured if required. To detect pregnancy, the same vets performed rectal palpation or ultrasonography 30 days after breeding. For accurate pregnancy confirmation, various techniques were used, such as rectal palpation, blood testing for pregnancy-specific proteins, ultrasound inspection, and behavioral observation. Early post-foaling estrus was the focus of the evaluation for foal heat conceptions, with a focus on the significance of accurate and timely pregnancy identification for successful reproductive management.

Statistical analysis

The normality of data was assessed using the Shapiro-Wilk test. The impact of independent variables on dependent variables was analyzed employing SPSS 27.0 through linear regression and ANOVA methods, maintaining a 95% confidence interval. For extrinsic and intrinsic factors, influencing foal growth, development, and broodmare performance, One-way ANOVA and regression analyses were applied. The effects of feed on foal growth were specifically scrutinized using the ANOVA method.

Results

Reproductive performance parameters among different breeds

Table 1 shows the comparison of various parameters related to the reproductive performance of Percheron, Arab, and Thoroughbred mares. Arab mares had a significantly higher number of foals ($p<0.05$) in 10 years compared to Percheron and Thoroughbred mares 5.45, 4.40, and 4.80

respectively. Arab mares had a significantly higher number of foal heat conceptions compared to Percheron and Thoroughbred mares (2.40, 1.75, and 1.80 respectively. Arab mares (43.95) had a significantly higher percentage of pregnancy at foal heat compared to Percheron (36.6) and Thoroughbred mares (33.95). Arab and Thoroughbred mares (16.00 and 17.6) had a significantly higher percentage of dystocia compared to Percheron mares (3.65). Arab mares were significantly younger at their first breeding as compared to Percheron and Thoroughbred mares.

Reproductive performance parameters among different management

The impact of different housing management (Excellent, Good, and Fair) on various parameters is shown in Table 2. There is a significant difference in the number of foals produced in 10 years among the different types of management ($p < 0.05$). Mares under excellent management produced the highest number of foals (5.89), while those under fair management produced the least (4.17 No). Mares under excellent management had the highest foal heat conceptions (2.67), while those under Fair management had the lowest (0.92). Mares under excellent management had the highest percentage, while those under Fair management had the lowest (45.11 and 18.58 respectively). Mares under Excellent management had no cases of dystocia (0.00 No), while those under Good and fair management had higher percentages of 14.67 and 14.42, respectively. There was no statistically significant difference in the age at first breeding among the different types of management ($p > 0.05$). The age at first breeding shows non-significant across all three managements.

Foal performance among different breeds

The foal performance between the breeds is shown in Table 3. Arab mares revealed significantly higher end-season fertility compared to Percheron and Thoroughbred mares (85%; 55%; and 65% respectively). Percheron mares (85%) and Thoroughbred mares (75%) exhibited significantly higher rates of normal foaling compared to Arab mares (60%). Percheron mares significantly outperformed Arab and Thoroughbred mares in producing healthy foals (100%; 70%; 75% respectively). The differences in foal survival rates among the three breeds show non-significant results.

Foal performance among different management

Foal performance among different management is shown in Table 4. The foal broodmares under excellent management (88.8%) demonstrated significantly higher end-season fertility compared to those under good (78.4%) and fair management (33.3%). Fair management shows in the lowest end-season fertility. Broodmares under excellent management had a significantly higher rate of normal foaling compared to those under good and fair management (100%; 64% and 83% respectively). Good management was linked with lower normal foaling rates. There is no statistical difference in the foals' health and survival among the different management types (p=0696; 0.964 respectively).

Discussion

To the best of our knowledge, this is the first investigation focusing on the reproductive performance of Arab, Percheron, and Thoroughbred mares specifically subtropical environmental conditions in Pakistan. The results of the retrospective study that was executed provide insightful information about the effects of various management techniques on the reproductive outcomes and foal performance of Percheron, Arab, and Thoroughbred mares. This retro-specific study had shown significant differences in the reproductive performance among the three breeds. Arab mares had a significantly higher number of foals produced in 10 years compared to Percheron and Thoroughbred mares. In several reproductive parameters, Arab mares performed better than Percheron and Thoroughbred mares. Arab mares produced 5.45, 4.40, and 4.80 foals, respectively. They also had a higher conception rate (2.40, 1.75, and 1.80, respectively) and a higher percentage of foals that were pregnant (43.9, 36.6, and 33.95%, respectively). Despite these achievements, the percentage of dystocia in Arab and Thoroughbred mares was significantly higher (16.0 and 17.60%, respectively) than in Percheron mares (3.65%). Arab mares' noticeably younger age also raises concerns regarding possible benefits and long-term effects at first breeding. Our results are consistent with [5] conclusions that Arab mares

showed better reproductive performance as compared to Thoroughbred mares. Mares maintain a year-round cyclic reproductive pattern, and Arab mares show higher conception rates in winter as opposed to summer. The results of this study show significant differences in the rates of conception that occur when Arabian mares (45% and 52%) and Thoroughbred mares (22% and 33%) breed during their respective second-mated estrus and foal heat-mated estrus. [15] reported that no summer stress affected the fertility of Thoroughbred mares in Indian subtropical conditions. The lower reproductive performance observed in comparison to temperate regions seems to be linked with differences in breeding management. Age is a significant factor influencing mare pregnancy rates, which is consistent with the results of other previous research [16, 17, 12]. In our study, Arab mares were significantly younger at their first breeding compared to Percheron and Thoroughbred mares. This finding could have practical implications for breeding programs, as it suggests that Arab mares reach sexual maturity at an earlier age. Our results are consistent with [18] that the existence of chronic and progressive degenerative abnormalities in the endometrium, the lining of the uterus, has been linked to the decline in fertility that occurs with age.

Furthermore, because of decreased uterine capability and inadequate urinary structure, which are symptoms of age, older mares may also show increased susceptibility to uterine infections[19]. All of these elements work together to cause the age-related reduction in Thoroughbred mares' ability to reproduce. Our results are also consistent with [20]. Age has a significant impact on the reproductive efficiency of mares that are bred during their foal heat (FH) phase. Older mares, specifically those at the age of 10 years, are recommended to be bred during their subsequent heat (SH) cycle. This practice aims to reduce early embryonic mortality (EmbM) and ultimately enhance the overall reproductive performance of older mares.

The results regarding housing management practices were evaluated, which highlighted how crucial management is to reproductive outcomes. Mares managed excellently have consistently performed better than those managed good or fair. The highest percentage of pregnancy at foal heat (45.11%), the highest foal heat conception rate (2.67), and the highest number of foals in ten years (5.89) were all correlated with excellent management. These outcomes resonate with the conclusions drawn in earlier studies performed by [21]. Interestingly, mares managed excellently had no cases of dystocia, compared with 14.67 and 14.42%, respectively, for mares managed well and poorly. The worth of the findings is boosted by the similarity to earlier research [22]. The lack of a significant difference in age at first breeding raises the possibility that management quality does not affect age-related variables.

There are statistically significant differences in the performance of foals between breeds. Compared to their Percheron (55%) and Thoroughbred (65%) counterparts, Arab mares exhibit a remarkable end-season fertility rate of 85%, indicating their extraordinary breeding potential. The current findings' reliability is highlighted by their similarities to earlier research [23]. On the other hand, Percheron mares stand out for having an astounding 85% normal foaling rate, which is higher than both Arab (60%) and Thoroughbred (75%) mares in this crucial area of foal delivery. It is interesting to note that, despite differences in survival rates between the three breeds, these differences did not reach statistical significance. These results are consistent with the findings of previous research executed [24]. This highlights the need for a more thorough investigation of factors influencing foal survival that may not be breed-specific. The similarities with earlier investigations demonstrate the validity of the current findings [25].

Evaluating foal's performance under various housing management also shows interesting results. Excellently managed broodmares had an impressive end-season fertility rate of 88.8%, far higher as compared to good (78.4%) and fair (33.3%) management. The findings are consistent with research conducted by other researchers on the reproductive success of European-bred thoroughbreds at various times of the year in mid-latitude conditions [26,27]. The notable variations in the typical foaling rates of the various management kinds highlight the important roles that housing management plays in the birthing process. Interestingly, there is a notable consistency in the health and survival of foals across the range of management practices, with no statistically significant differences despite these variations in foaling outcomes. The findings align closely with investigations conducted by other researchers [28, 29]. This highlights how important careful management is to maximize fertility while

maintaining uniform standards for the welfare of the foals, regardless of the level of management experience.

This study provides insightful information about the complex interactions between breed and housing management that affect the development of mare reproduction and foaling. Incorporating particular numerical values improves the numerical understanding of observed patterns and emphasizes how important it is to choose the right breeds and use good management practices to achieve maximum reproductive success. More research is necessary for a deeper comprehension as it is necessary to fully clarify the underlying causes of dystocia rates and assess the long-term effects of early breeding in Arabian mares.

Conclusion

In summary, this study thoroughly examined the reproductive potential of three different broodmares raised in Pakistan's subtropical environment, considering various factors and management practices. The mares included were Percheron, Arab, and Thoroughbred. Higher foal numbers and conception rates were observed in Arab mares, which also showed improved reproductive results. However, there were significant variations in the health and productivity of foals under different housing management. The results highlighted the complex relationship that exists between breed, management, and reproductive success and indicated the necessity for specialized methods to maximize reproductive outcomes for horses in subtropical climates.

Conflicts of interest

The authors declare no conflicts of interest.

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Table 1: Effect of different breeds of mares on various reproductive traits Values in the same rows with different superscripts are different (p<0.05)

Sr No	Parameter	Unit	Number of Mares of each breed (n=40)			
			Percheron	Arab	Thoroughbred	*p*-value
01	Number of foals in 10 years	No.	4.40 ± 0.171	5.45^{a} ± 0.138	4.80^{b} ± 0.206	0.00

02	Foal heat conceptions	No.	1.75 ± 0.16	2.40[a]±0.13	1.80[b] ± 0.19	0.007
03	Percent of pregnancy at foal heat	No.	36.60[b]± 2.81	43.95[a] ± 2.01	33.95[c]± 2.92	0.022
04	Percentage of dystocia	No.	3.65[c] ± 1.44	16.00[b] ± 3.52	17.60[a] ± 3.31	0.001
05	Age at first breeding	Days	1466.30[b] ± 5.40	1284.05[c]± 5.98	1485.5[a]±57.62	0.000

Table 2: Effect of different management on various reproductive traits

Sr No	Parameter	Unit	Type of Management			
			Excellent (n=18)	**Good (n=78)**	**Fair (n=24)**	***p*-Value**
01	Number of foals in 10 years	No.	5.89[a] ± 0.137	4.87[b]±0.124	4.17[c]±0.253	0.000
02	Foal heat conceptions	No.	2.67[a] ± 0.11	2.15[b] ± 0.09	0.92[c] ± 0.25	0.000
03	Percent of pregnancy at foal heat	No.	45.11[a]±1.45	42.59[b] ±1.25	18.58[c] ± 4.76	0.000
04	Percentage of dystocia	%age	0.00 ± 0.00	14.67 ± 2.21	14.42 ± 4.57	.011
05	Age at first breeding	Days	1410.22 ± 26.36	1413.43± 11.03	1408.50 ± 20.71	0.975

Values in the same rows with different superscripts are different ($p<0.05$)

Table 3: Comparative Analysis of Foaling Performance among Different Breeds of Broodmares

Sr No.	Parameter	Breed of Mares			
		Percheron (n=40)	**Arab (n=40)**	**Thoroughbred (n=40)**	***p*-Value**
01	End-season fertility (%age)	55% (22/40)	85% (34/40)	65% (26/40)	0.012
02	Normal foaling	85% (34/40)	60% (24/40)	75% (30/40)	0.043
03	Healthy foals	100% (40/40)	70% (28/40)	75% (30/40)	0.001
04	Foal survival	90% (36/40)	70% (28/40)	80% (32/40)	0.082

Table 4: Comparative Analysis of Foaling Performance among Different Management

Sr No	Parameter	Type of Management			
		Excellent (n=18)	**Good (n=78)**	**Fair (n=24)**	***p*-Value**
01	End-season fertility (%age)	88.8% (16/18)	78.4% (58/78)	33.33% (8/24)	0.000
02	Normal foaling	100% (18/18)	64% (50/78)	83% (20/24)	0.002
03	Healthy foals	88.9% (16/18)	79.5% (62/78)	83.3% (20/24)	0.696
04	Foal survival	88.9% (16/18)	79.5% (62/78)	75% (18/24)	0.564