Factors affecting estrus response and conception rates following artificial insemination in dairy farms of Northeast Algerian

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ABSTRACT

Fertility in dairy cows is determined by accurate hormonal control and well-timed insemination, which depend on genetic background, parity, and the period between calving and insemination. Optimizing these factors is associated with efficient ovulation, clear estrus behavior, and improved conception outcomes. This study examined how breed, parity, and the calving-to-first-insemination interval (IC–AI1) influence estrus expression and conception rate after hormonal synchronization and artificial insemination in Algerian dairy herds. A total of 105 healthy cows aged 2–5 years (66 Montbéliarde and 39 Prim'Holstein) with body condition scores ≥2 were enrolled from two intensive farms in Setif, northeastern Algeria. Animals received prostaglandin $F_2\alpha$ ($PGF_2\alpha$) alone or combined with gonadotropin-releasing hormone (GnRH).. Estrus detection was performed visually, and pregnancy was confirmed by ultrasonography at 30 days followed by rectal palpation at 45 days. Overall estrus expression was moderate (53%), while conception success reached 70%, aligning with results from efficiently managed herds. The $PGF_2\alpha$-only treatment yielded the best performance. Parity significantly affected estrus manifestation ($p < 0.05$), with multiparous cows exhibiting more visible heat signs, whereas longer IC–AI1 intervals were associated with higher conception rates ($p < 0.05$). Breed had no marked influence. These findings indicate that a simple $PGF_2\alpha$-based protocol can produce satisfactory fertility outcomes in Algerian conditions. Considering parity and insemination timing may further enhance reproductive success. Broader studies integrating nutritional and health factors are recommended to better understand their combined effects on fertility

Keywords: Artificial insemination, Breed, Conception rate, Dairy cow, Estrus rate, IC-IA1, Parity.

1. Introduction

Reproductive efficiency in dairy herds has shown a steady decline over recent decades, mainly as a consequence of the genetic and management emphasis on milk yield [1]. In Algeria, dairy cattle provide nearly 80% of the national milk supply, yet the overall herd size has diminished in recent

years. The national dairy herd is estimated at about one million head, among which imported dairy breeds—principally Holstein (H), Montbéliarde (MB), and Fleckvieh (FV)—represent approximately 30% [2].

The Sétif region, located in northeastern Algeria, is one of the country's leading dairy production zones, with around 77,000 cows [3]. Despite this potential, reproductive inefficiency remains a limiting factor for productivity. Declining fertility indices and longer calving intervals have hindered the goal of achieving one calf per cow per year, thereby affecting the profitability of farms.

Reproductive management tools such as estrus synchronization and artificial insemination (AI) are widely used to enhance fertility and accelerate genetic improvement [5]. However, variable results among farms highlight the influence of local conditions and management practices. This study provides new insights by directly comparing the reproductive performance of cows treated with prostaglandin $F_2\alpha$ ($PGF_2\alpha$) alone versus combined hormonal protocols under field conditions in Sétif. We also investigated how breed, parity, and the interval from calving to first insemination (IC–AI1) influence estrus expression and conception rates, aiming to generate practical recommendations for improving fertility management in Algerian dairy herds.

2. Material and Methods

2.1. Study location

This research was carried out on two intensive dairy farms situated in the Sétif region of northeastern Algeria (36°11′N, 5°24′E; 1,080 m elevation). The trial was carried out during spring (March–June), characterized by moderate temperatures (18–28°C) and low thermal stress. A total of 105 cyclic cows and heifers were selected after confirming normal reproductive status by rectal palpation. The group included 39 primiparous (PP) and 66 multiparous (MP) animals, aged between 2 and 5 years. The herd consisted of 66 Montbéliarde (MB) and 39 Prim'Holstein (PH) cows. All animals were clinically healthy, free from structural defects, and maintained a body condition score (BCS) greater than 2 on a 1–5 scale, as described by Campanile et al. [6]. Reproductive procedures were conducted between 55 and 90 days postpartum.

Throughout the experiment, all cows were managed under uniform housing, feeding, and breeding conditions. Animals presenting any postpartum disorders (retained placenta, metritis, or endometritis) were excluded from the study population. Animals were kept apart from the general herd until artificial insemination was completed.

Reproductive performance indicators were assessed as follows:

- **Estrus response rate (ER)**: defined as the total number of cows/heifer observed in estrus divided by the total number of females subjected to reproduction in each group X 100.
- **Conception rate**: defined as the total number of cows/heifer pregnant divided by the total number of inseminated females in each group x 100.

2.2. Experimental Protocols

The cows were randomly distributed into three experimental groups of 35 animals each. One group received two injections of prostaglandin $F_2\alpha$ ($PGF_2\alpha$) alone, while the other two groups were treated

with $PGF_2\alpha$ in combination with either a single (GP) or double (GPG) administration of gonadotropin-releasing hormone (GnRH).

2.3 Determination of factors effects

Three main factors were evaluated in this study: **breed**, **parity**, and the **interval between calving and first insemination (IC–AI1)**.

- The cows belonged to two genetic groups: *Prim'Holstein (PH)* and *Montbéliarde (MB)*.
- Animals were also categorized according to parity into *primiparous (PP)* and *multiparous (MP)* groups.
- The calving-to-insemination interval was classified into two periods: *Class 1* (55–69 days postpartum; n = 76) and *Class 2* (70–90 days postpartum; n = 29).

2.4. Estrus Detection and Pregnancy Diagnosis

Estrus detection was performed through direct visual observation, as automated detection systems were unavailable on the participating farms. Despite its limitations, visual detection remains a valid approach in field conditions when performed by trained staff [26, 27]. Lack of heat-detection aids (tail chalking, pedometers, activity monitors) may have under-estimated estrus expression, representing a known limitation of this study.

Artificial insemination (AI) was performed when cows exhibited visible signs of estrus. Heat detection was carried out through visual observation twice daily, each session lasting approximately 30 minutes. To eliminate operator bias, all inseminations were performed by a single experienced veterinarian from CNIAAG. The presence and consistency of cervical mucus on the day of insemination were also considered to confirm estrus. Pregnancy was diagnosed by ultrasonography 30 days after insemination and verified through rectal palpation at 45 days post-AI.

Semen used for insemination was supplied by the **National Center for Artificial Insemination and Genetic Improvement (CNIAAG)**. It originated from two bulls: *INDOR* (Montbéliarde breed) and *HAELTOP* (Holstein breed). All inseminations were conducted by a CNIAAG-certified veterinarian. The potential influence of the sire was additionally evaluated with respect to conception rate and offspring sex ratio.

To ensure semen consistency, inseminations were carried out using semen from two CNIAAG-proven bulls with similar fertility indices, and the same semen batch was used across all treatments.

2.5. Statistical Analysis

Data analysis was performed using **SAS software (version 9.12)**. The main objective was to evaluate how different synchronization treatments influenced estrus response, pregnancy, and conception rates among the experimental groups. Differences in reproductive performance between groups were tested using the **Chi-square (χ^2) test**, and results were considered statistically significant at $\mathbf{p < 0.05}$. The normality of continuous variables was verified using the Shapiro–Wilk test. Chi-square analysis was complemented by descriptive statistics (mean ± SD), and 95% confidence intervals (CI) were calculated where appropriate.

3. Results

3.1. Evaluation of reproductive performances

This experiment assessed reproductive performance in *Prim'Holstein* and *Montbéliarde* dairy cows, focusing on estrus response and conception rates. Table 1 summarizes the overall outcomes for these parameters. Estrus detection was based on behavioral observation, particularly when a cow stood immobile while being mounted by another. Fecundity was evaluated using the interval from calving to first insemination (IC–AI1), while fertility was measured through the conception rate.

Out of 105 cyclic cows subjected to synchronization treatments using either prostaglandin alone or prostaglandin combined with GnRH, 57 animals (53%) exhibited visible estrus, and 40 of these (70%) conceived successfully. The prostaglandin-only protocol produced the most favorable reproductive outcomes, with an estrus response of 60% and a conception rate of 75%, compared to 50% and 65% in the combined $PGF_2\alpha$ + GnRH groups, respectively.

The prostaglandin-only protocol produced the most favorable reproductive outcomes, with superior estrus response and conception performance compared to combined treatments.

Table 1. Comparative effectiveness between protocols based on prostaglandins alone or combined to PGF2αin Algerian cattle breeding (n=105)

	Heat induction protocols			
Reproductive performance	**PGF2α**	**GPG**	**GP**	**Average**
Estrus response rate	**74%**	**49%**	**40%**	**53%**
Conception rate	**73%**	**65%**	**71%**	**70%**

3.2. Factors influencing the fecundity and fertility

The study also examined several sources of variation, namely breed, parity, and the interval from calving to first insemination (IC–AI1). The influence of these factors on reproductive performance is summarized in Table 2.

With regard to breed, *Montbéliarde* cows showed a slightly higher estrus response rate compared to *Prim'Holstein* cows (56.06% vs. 51.28%; $P = 0.497$). Similarly, conception rates were comparable between the two breeds (70.72% vs. 70.00%; $P = 0.966$). These results indicate no statistically significant differences ($P > 0.05$) in either estrus response or conception performance between breeds.

For parity, out of the 57 cows that displayed estrus, 16 were primiparous (16/39; 41.02%) and 41 were multiparous (41/66; 62.12%). This difference was significant ($P < 0.05$), indicating that older cows expressed estrus more frequently than heifers. Conception rate also varied slightly between these groups, with 62.5% (10/16) in primiparous and 73.17% (30/41) in multiparous cows ($P = 0.106$), though this difference was not statistically significant.

Concerning the IC–AI1 interval, average estrus detection was similar between cows inseminated within 55–69 days and those inseminated between 70–90 days postpartum (62.53% vs. 58.62%; $P = 0.393$).

However, conception rate was significantly higher in cows bred after 70 days postpartum (82.35%) compared to those inseminated earlier (65%; $P < 0.05$). This suggests that extending the interval between calving and insemination improves conception outcomes.

Table 2. Influencing factors on overall estrus response and conception rates in Algerian cattle breeding (n=105)

Variable	N	Estrus response rate	P. Value	Conception rate	P. Value
Breed					
PH	39	51.28		70.00	
			0.497		0.966
MB	66	56.06		70.72	
Parity					
PP	39	41.02		62.50	
			0.0028		0.106
MP	66	62.12		73.17	
IC-IA1					
First class	76	52.63		65.00	
			0.393		0.024
Second class	29	58.62		82.35	

Legend: PH: Prim Holstein; MB: Montbeliard; PP: Primiparous; MP: Multiparous;
IC-IA1: Interval calving–First artificial insemination; First class: 55-69 D; Second class: 70-90 D.

4. Discussion

The estrus response rate obtained in this study was higher than that reported by Demetrio et al. [1] in Holstein cows but lower than those observed by Colazo and Ambrose [7] and Raphalalani et al. [7], who recorded 68% and 75%, respectively. This difference may be attributed to variations in synchronization protocols, especially those using hormonal combinations beyond prostaglandins. Non-responding cows might have failed to exhibit behavioral signs of estrus due to the absence of mounting partners or silent heat episodes. Çevik et al. [8] noted that estrus detection rates below 50% are frequent in dairy herds, particularly in high-yielding cows, where increased milk production is associated with lower circulating estradiol and shorter estrus periods. Furthermore, as Rao et al. [9] indicated, mounting frequency tends to increase when several cows are simultaneously in heat, improving detection rates.

The conception rate reported in this study is comparable to that obtained by Mouffok et al. [10] in eastern Algeria (64%) and Belay et al. [11] in Ethiopia (60.4%). Such variation could be related to differences in hormonal treatments, environmental conditions, and management systems. Nutritional and metabolic status are known to affect fertility, especially during early lactation when energy deficits are common [5,12]. Additionally, environmental stresses such as high temperature and prolonged drought may impair fertilization and embryo survival [13].

Regarding **breed influence**, Montbéliarde cows showed slightly higher estrus response rates than Prim'Holstein cows, although the difference was not significant. Literature indicates that fertility varies among breeds; Holsteins typically exhibit lower reproductive performance and longer calving-to-conception intervals compared to dual-purpose breeds [14–16]. The weaker estrus signs in Prim'Holstein cows could be related to shorter or silent heat, as reported by Tada et al. [15]. Bouamra et al. [16] also found a longer calving-to-first-AI interval in Holsteins compared to Montbéliardes. The present results were lower than those reported by Ben Salem et al. [17] in Tunisia and by Mouffok et al. [10] in Algeria. Breed differences in estrus behavior, including shorter estrus duration and fewer mounting activities, were also highlighted by Orihuela [18], who noted that cattle raised on pasture spend less time expressing estrus. Similarly, zebu breeds are known to exhibit shorter and less intense estrus compared to exotic breeds [19].

With respect to **fertility parameters**, Prim'Holstein cows achieved a conception rate of 70%, which exceeds the 40% reported by Ben Salem et al. [17]. Since all animals were kept under identical management and nutrition, this variation is likely due to genetic differences and reproductive history, particularly postpartum recovery and milk yield. High-producing cows are more prone to thermal stress, which negatively affects fertility [20,21]. This highlights the need to balance selection for milk production with reproductive performance. However, as fertility traits are generally low in heritability and difficult to measure, indirect indicators such as body condition score or milk fatty acid profile, as proposed by Miglior et al. [12], may be useful alternatives in selection programs.

Concerning parity, our results showed that multiparous cows exhibited higher estrus expression than primiparous cows, although conception rates were not significantly different. While some studies [22] suggest that primiparous cows respond better to estrus synchronization, this discrepancy may reflect differences in energy balance, milk production, or management conditions. In our study, multiparous cows may have expressed estrus more visibly due to stronger behavioral signs, even if their overall conception advantage was minimal. Lane et al. [23] also reported that parity had no significant effect on fertility ($p > 0.05$), supporting the idea that observed differences in estrus expression do not necessarily translate to large differences in conception outcomes.

Regarding the **interval between calving and first insemination (IC–AI1)**, most dairy farmers tend to increase this interval for high-yielding cows, believing it improves conception rates. Buckley et al. [24] reported higher first-service conception rates when this interval exceeded 75 days, while Pursley et al. [25] found lower pregnancy rates in cows inseminated between 60 and 75 days postpartum. This has been attributed to the negative energy balance and incomplete uterine recovery occurring during the early postpartum period [13]. Extending the voluntary waiting period allows the reproductive tract and the hormonal system to return to normal function before insemination.

This study demonstrates that fertility in dairy cows is influenced by several factors, particularly parity and the interval between calving and first insemination (IC–AI1). Although breed differences were not significant, Montbéliarde cows tended to show slightly better estrus response. Prolonging the IC–AI1 interval beyond 70 days postpartum improved conception success.

However, some methodological limitations should be acknowledged. Estrus detection was performed only visually, twice daily, without the use of detection aids such as tail chalking, pedometers, or activity monitors, which may have led to an underestimation of estrus expression. Another limitation of this study is the unbalanced sample sizes between IC–AI1 groups (76 vs 29), which may have affected the statistical power and precision of the comparison. Finally, nutritional status and health parameters were not systematically recorded, which could influence estrus expression and conception outcomes.

Future studies involving larger herds and considering additional health, nutritional, and genetic parameters are needed to better identify the key determinants of reproductive efficiency in Algerian dairy systems.

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Ethical approval

Experimental procedures approved by the Institutional Committee for the Protection of Animals of the National Administration of Higher Education and Scientific Research of Algeria (98-11, Act of 22 August 1998).

CRediT authorship contribution statement

Study concept and design: A.B. and A.N; Conducting the experiment: A.B. and A.N; Analysis and interpretation of data: N.O. and N.A.K.T; Drafting of the manuscript: N.M., O.S. and N.A.K.T; Critical revision of the manuscript: A.B., A.N., N.O. and N.A.K.T.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence
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Data Availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Declaration of AI use:

No AI-assisted technologies were used in the preparation or editing of this manuscript.

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