International Journal of Genetics and Genomics
2025, Vol. 13, No. 3, pp. 51-56
https://doi.org/10.11648/j.ijgg.20251303.11

Research Article

Meta-analysis on Performance for Reproductive Traits of Jersey Cross, 50% HF and 75% HF Cross Dairy Cattle in Ethiopia

Danayit Alem*, Nibo Beneberu

Ethiopian Institute of Agricultural Research, Holetta Agricultural Research Center, Holetta, Ethiopia

Abstract

This review aimed to evaluate the reproductive performance of Jersey cross, 50% HF cross, and 75% HF cross dairy cattle in Ethiopia. Data from 287 crossbred cattle records were analyzed to assess traits including age at first service (AFS), age at first calving (AFC), calving interval (CI), days open (DO), and number of services per conception (NSPC). Statistical analysis was conducted using SAS 9.0 and SPSS 22.0. Overall means (± SD) were 30.68 ± 4.76 months for AFS, 40.99 ± 4.95 months for AFC, 456.93 ± 49.16 days for CI, 147.40 ± 43.74 days for DO, and 1.69 ± 0.28 for NSPC. Genetic group did not significantly ($p > 0.05$) influence reproductive traits. However, 75% HF crosses exhibited superior AFS and NSPC, while 50% HF crosses had shorter CI, and Jersey crosses showed better AFC and DO. Phenotypic correlations among reproductive traits were predominantly low and positive (e.g., 0.244 between CI and NSPC), except for a weak negative correlation (-0.072) between AFS and AFC. The findings suggest that 75% HF crossbred cow's demonstrated favorable reproductive outcomes in select traits. To optimize reproductive performance, improvements in heat detection, timely insemination, health management, and genetic strategies for crossbreeding are recommended.

Keywords

Crossbred Dairy Cattle, Phenotypic Correlation, Smallholder Dairy Systems, Reproductive Performance

1. Introduction

Crossbreeding has been widely adopted as a strategy to enhance the productivity and reproductive performance of dairy cattle in tropical regions, including Ethiopia, where indigenous breeds often exhibit low milk yield and reproductive efficiency [1]. The introduction of exotic dairy breeds, such as Holstein Friesian (HF) and Jersey, has been pursued to improve the genetic potential of local cattle populations, particularly for milk production and reproductive traits [2]. However, the performance of crossbred cattle is influenced by the level of exotic inheritance, management practices, and environmental [3].

Reproductive performance is a critical factor in determining the profitability and sustainability of dairy farming. Key reproductive traits, such as age at first service (AFS), age at first calving (AFC), calving interval (CI), days open (DO), and number of services per conception (NSPC), directly impact the lifetime productivity of dairy cows [4]. While crossbreeding has shown potential to improve these traits, the

*Corresponding author: danay7521@gmail.com (Danayit Alem)

Received: 31 March 2025; **Accepted:** 21 June 2025; **Published:** 8 July 2025

optimal level of exotic inheritance remains a subject of debate, particularly under low-input production systems prevalent in developing countries [5].

Recent studies have highlighted the variability in reproductive performance among different crossbred genotypes. higher levels of exotic inheritance (75% HF) have been associated with improved milk production but may also pose challenges related to adaptability and reproductive efficiency under suboptimal management conditions [6]. Conversely, lower levels of exotic inheritance (50% HF) may offer a balance between productivity and adaptability, making them more suitable for smallholder dairy systems [7].

Despite the growing body of research on crossbred dairy cattle in Ethiopia, there is a need for comprehensive reviews that synthesize existing data to provide evidence-based recommendations for breeding and management strategies. This review aims to evaluate the reproductive performance of Jersey cross, 50% HF cross, and 75% HF cross dairy cattle, with a focus on identifying the most suitable genotypes for sustainable dairy production under Ethiopian conditions.

2. Materials and Methods

2.1. Study Design and Data Collection

This review was conducted to evaluate the reproductive performance of crossbred dairy cattle, specifically focusing on Jersey cross, 50% HF cross, and 75% HF cross genotypes in Ethiopia. Data were collected from both published and unpublished sources, including research articles, technical reports, and institutional records. A total of 156 reproductive performance records of crossbred dairy cattle were compiled, covering key reproductive trait such Age at first services (AFS), Age at first calving (AFC), calving interval (CI), Days open (DO) and Number of service per conception (NSPC). The data spanned various agro-ecological zones and management systems to ensure representativeness.

2.2. Data Analysis

The collected data were analyzed using statistical software SAS (version 9.0). Descriptive statistics, including means and standard deviations, were calculated for each reproductive trait. The effect of genetic group (Jersey cross, 50% HF cross, and 75% HF cross) on reproductive performance was assessed using one-way analysis of variance (ANOVA). Phenotypic correlations among reproductive traits (AFS, AFC, CI, DO and NSPC) were also computed to understand the relationships between these traits and their potential implications for selection and breeding programs.

2.3. Variables and Measurements

The reproductive traits evaluated in this study were defined as follows:

Age at first service (AFS): The age at which a heifer first receives artificial insemination or mates.

Age at first calving (AFC): The age at which a cow gives birth for the first time.

Calving Interval (CI): The time between two successive calving's.

Days open (DO): The number of days between calving and successful conception.

And *Number of services per conception (NSC):* The average number of inseminations or mating required for a cow to conceive.

2.4. Statistical Models

Statistical Model for Analysis of reproductive traits

$$Yin = \mu + Yi + ein$$

Where:

Yin = AFS, AFC, CI, DO and NSC trait of ith Animal group

μ = overall mean

Yi = the effect of ith Animal group (I = Jersey cross, 50% HF cross and 75% HF cross)

Ein = random error associated with each observation

3. Results and Discussion

3.1. Age at First Service (AFS)

The variability in the age at first service (AFS) among different genetic groups of crossbred cows, including Jersey cross, 50% HF, and 75% HF. The overall mean AFS of 30.68 ± 4.76 months with a coefficient of variation (CV) of 15.51% indicates moderate variability across the studied populations. This finding aligns with previous studies by [8, 9], who reported similar AFS values for HF x Boran and 93.75% HF crossbred cows, respectively. However, the AFS in this review is longer than the 18.96 months reported by [10] for HF x Fogera crossbred cows on farms, but shorter than the 40.9 ± 0.33 months reported by [11] for HF x Boran crossbred cows on-station. These discrepancies may be attributed to differences in management practices, genetic composition, and environmental conditions.

The lack of a significant effect ($p > 0.05$) of genetic group on AFS suggests that factors other than genetics, such as management, nutrition, and production systems, play a more critical role in determining the age at which heifers are first serviced. This is consistent with findings by [12], who emphasized that poor feeding and low management levels during early stages of life can delay growth and puberty, leading to an extended AFS. Similarly, [13] highlighted the importance of optimizing breeding seasons to coincide with periods of high forage quality and quantity, which can promote early service and improve reproductive efficiency.

Recent studies further support the idea that management and nutritional interventions are key to reducing AFS. For instance, [14] found that improved feeding strategies and health management significantly reduced AFS in smallholder dairy systems. Additionally [1] reported that crossbred heifers reared under intensive management systems achieved earlier AFS compared to those under traditional systems, underscoring the importance of targeted interventions.

In conclusion, while genetic factors may contribute to some variation in AFS, the primary drivers appear to be management practices, nutritional status, and production systems. Addressing these factors through improved feeding, health management, and strategic breeding practices can help achieve earlier AFS, thereby enhancing reproductive performance and overall productivity in crossbred dairy cows.

3.2. Age at First Calving (AFC)

The results reveal significant variability in the age at first calving (AFC) among crossbred cows, including Jersey cross, 50% HF, and 75% HF genetic groups. The overall mean AFC of 40.99 ± 4.95 months, with a coefficient of variation (CV) of 12.08%, indicates moderate variability across the studied populations. This finding is consistent with earlier studies by [15] and [16], who reported similar AFC values for 75% HF x local (F2) and 75% HF crossbred cows, respectively. However, the AFC in this review is lower than values reported by [17-19], and [13], who observed longer AFCs for Jersey x GH, F2 Friesian, and 75% HF x Borena crossbred cows. Conversely, the AFC in this review is longer than findings by [20, 10], and [21], who reported shorter AFCs for 50% Jersey x Arsi, HF x Fogera, and 75% HF x local crossbred cows.

The lack of a significant effect ($p > 0.05$) of genetic group on AFC suggests that non-genetic factors, such as feeding management, heat detection, timely insemination, health control, and climate, play a more critical role in determining AFC. This aligns with [22], who emphasized that AFC is influenced by nutrition, year and month of birth, and rearing intensity. Similarly, [12] highlighted that poor feeding and management during early life stages can delay growth and puberty, leading to extended AFC.

Recent studies further support the importance of management and nutritional interventions in reducing AFC. For instance [1] found that crossbred heifers under intensive management systems achieved earlier AFC compared to those under traditional systems. [14] also reported that improved feeding strategies and health management significantly reduced AFC in smallholder dairy systems. These findings underscore the need for targeted interventions to optimize heifer rearing practices and improve reproductive efficiency.

In conclusion, while genetic factors may contribute to some variation in AFC, the primary drivers appear to be management practices, nutritional status, and environmental conditions. Addressing these factors through improved feeding, health management, and strategic breeding practices can help achieve earlier AFC, thereby enhancing reproductive performance and overall productivity in crossbred dairy cows.

3.3. Calving Interval (CI)

The results highlight the variability in calving intervals (CI) among crossbred cows, including Jersey cross, 50% HF, and 75% HF genetic groups. The overall mean CI of 456.93 ± 49.16 days is significantly longer than the ideal CI of 365 days, which is considered optimal for dairy cattle to maximize milk production and reproductive efficiency [23]. This result aligns with findings by [19, 15], who reported similar CIs for 50% HF x local (F3) and 50% F2 Friesian crossbred cows, respectively. However, the CI in this review is shorter than values reported [17, 18], and [13] for Jersey x GH, F2 Friesian, and 50% F2 Friesian crossbred cows, but longer than the 351.2 ± 10.9 days reported by [20] for 50% Jersey x Arsi (F1) crossbred cows.

The lack of a significant effect ($p > 0.05$) of genetic group on CI suggests that non-genetic factors, such as management practices, environmental conditions, and geographical location, play a more critical role in determining CI. This is consistent with [12] and [13], who emphasized that poor management practices, heat detection, and environmental stressors can delay the return to estrus and conception, leading to extended CIs. Additionally, [24] highlighted that CI is a crucial index of reproductive performance, as it directly impacts total milk production and the number of calves born.

Recent studies further support the importance of management and environmental factors in optimizing CI. For instance, [1] found that improved feeding strategies, health management, and timely heat detection significantly reduced CI in smallholder dairy systems. Similarly, [14] reported that crossbred cows under intensive management systems achieved shorter CIs compared to those under traditional systems, underscoring the need for targeted interventions to improve reproductive efficiency.

In conclusion, while genetic factors may contribute to some variation in CI, the primary drivers appear to be management practices, environmental conditions, and geographical location. Addressing these factors through improved feeding, health management, and strategic breeding practices can help achieve shorter CIs, thereby enhancing reproductive performance and overall productivity in crossbred dairy cows.

3.4. Days Open (DO)

The results reveal significant variability in days open (DO) among crossbred cows, including Jersey cross, 50% HF, and 75% HF genetic groups. The overall mean DO of 147.40 ± 43.74 days indicates considerable variability across the studied populations. This result is slightly lower than the findings

of [13], who reported longer DOs for 75% F1 Friesian and 50% F2 Friesian crossbred cows at Holetta Research Center. However, the DO in this review is higher than values reported by [20] and [25] for 50% Jersey x Arsi (F1), 50% Friesian x Arsi (F1), and Jersey x Horro crossbred cows, respectively. The minimum and maximum DO values in this review were 76.30 and 243.03 days, respectively, highlighting the wide range of reproductive performance across different management systems and genetic groups.

The lack of a significant effect ($p > 0.05$) of genetic group on DO suggests that non-genetic factors, such as management practices, nutritional status, and environmental conditions, play a more critical role in determining DO. This aligns with [13, 8, 19], who emphasized that feed shortages, both in quality and quantity, and high milk production can delay the return to estrus and extend DO. High-producing cows often experience negative energy balance during early lactation, which can suppress reproductive function and prolong the interval to conception [25]. Additionally, [12] highlighted that poor heat detection and suboptimal insemination practices can further exacerbate DO.

Recent studies further support the importance of management and nutritional interventions in reducing DO. For instance, [1] found that improved feeding strategies, health management, and timely heat detection significantly reduced DO in smallholder dairy systems. Similarly, [14] reported that crossbred cows under intensive management systems achieved shorter DOs compared to those under traditional systems, underscoring the need for targeted interventions to improve reproductive efficiency.

In conclusion, while genetic factors may contribute to some variation in DO, the primary drivers appear to be management practices, nutritional status, and environmental conditions. Addressing these factors through improved feeding, health management, and strategic breeding practices can help achieve shorter DOs, thereby enhancing reproductive performance and overall productivity in crossbred dairy cows.

3.5. Number of Service Per Conception (NSPC)

The results highlight the variability in the number of services per conception (NSPC) among crossbred cows, including Jersey cross, 50% HF, and 75% HF genetic groups. The overall mean NSPC of 1.69 ± 0.28 is within an acceptable range, as values higher than 2 are considered poor [26]. This result aligns with the findings of [21], who reported a similar NSPC for 25% HF x Local crossbred cows. However, the NSPC in this review is slightly higher than values reported by [18] and [13] for 75% Jersey and 75% F2 Friesian crossbred cows, respectively, but lower than the findings of [16] for 50% HF and 75% HF crossbred cows. The minimum and maximum NSPC values in this review were 1.23 and 2.20, respectively, indicating variability in reproductive efficiency across different management systems and genetic groups.

The lack of a significant effect ($p > 0.05$) of genetic group on NSPC suggests that non-genetic factors, such as management practices, insemination techniques, and environmental conditions, play a more critical role in determining NSPC. This is consistent with [13, 27, 28], who emphasized that inconsistent feeding management, poor heat detection, inseminator skill, semen quality, and environmental variability can negatively impact conception rates. High milk yield and lactation length can also contribute to extended NSPC, as high-producing cows often experience negative energy balance, which can suppress reproductive function [25]. Additionally, silent ovulation and suboptimal insemination timing can further reduce conception rates [12].

Recent studies further support the importance of management and nutritional interventions in reducing NSPC. For instance, [1] found that improved feeding strategies, health management, and timely heat detection significantly reduced NSPC in smallholder dairy systems. Similarly, [14] reported that crossbred cows under intensive management systems achieved lower NSPC compared to those under traditional systems, underscoring the need for targeted interventions to improve reproductive efficiency.

In conclusion, while genetic factors may contribute to some variation in NSPC, the primary drivers appear to be management practices, nutritional status, and environmental conditions. Addressing these factors through improved feeding, health management, and strategic breeding practices can help achieve lower NSPC, thereby enhancing reproductive performance and overall productivity in crossbred dairy cows.

3.6. Phenotypic Correlation

Correlations are measures of the strength of the relationship between two variables, and they play a crucial role in predicting the response to selection in one trait due to selection in another [29]. In this review, phenotypic correlations were estimated between reproductive traits. Age at first service (AFS) and age at first calving (AFC) showed a positive correlation with calving interval (CI), number of services per conception (NSPC), and days open (DO). This finding aligns with [13], who reported that AFS was negatively correlated with CI, DO, and NSPC, while AFC was negatively correlated with CI and DO but positively correlated with NSPC.

4. Conclusion

This review assessed the reproductive performance of Jersey cross, 50% HF cross, and 75% HF cross dairy cattle in Ethiopia. The findings indicate that genetic group had no significant effect on reproductive traits, emphasizing the crucial role of management, nutrition, and breeding practices. Among the genetic groups, 75% HF crosses demonstrated superior AFS and NSPC, while 50% HF crosses had shorter

CI, and Jersey crosses exhibited better AFC and DO. Phenotypic correlations among reproductive traits were generally weak, highlighting the complexity of genetic and environmental interactions. To enhance reproductive performance, strategies such as improved heat detection, timely insemination, optimal feeding, and better herd management are essential. Additionally, further research is needed to refine breeding strategies that balance productivity with adaptability to Ethiopia's diverse agro-ecological conditions.

Abbreviations

AFC	Age at First Calving
AFS	Age at First Service
CI	Calving Interval
DO	Days Open

Author Contributions

Danayit Alem: Conceptualization, Validation, Writing – review & editing

Nibo Beneberu: Data curation, Formal Analysis, Writing – original draft

Conflicts of Interest

The authors declare no conflicts of interest.

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