OPEN ACCESS Freely available online

ISSN: 2161-1041
Hereditary Genetics: Current Research

Research Article

Horro and their Crossbred Dairy Cow's Reproductive Performance in Ethiopia Subhumid Tropical Environments

Beshatu Jalata[1], Habtamu Abera Goshu[2*], Tesfaye Mediksa[3], Dereje Bekele[3], Mohammed Aliye[4]

[1]Department of Animal Sciences, Asosa University, Asosa, Ethiopia; [2]Department of Genetics and Molecular Breeding, Bio and Emerging Technology Institute (BETin), Addis Ababa, Ethiopia; [3]Department of Agriculture, Bako Agricultural Research Center, Bako, Ethiopia; [4]Department of Animal Science, Jimma University, Jimma, Ethiopia

ABSTRACT

The estrus detection system, proper time of insemination, feeding, and health care practices each make a significant contribution towards the herd's optimal breeding efficiency and lifetime production. In the subhumid environments of Ethiopia, the age at first calving, days open, calving to first heat and services per conception are economic traits in the reproductive performance of Horro and their crossbred dairy cows. As a result, data collected at Ethiopia's Bako agricultural research center from 1980 to 2019 were used to study the reproductive performance of Horro and their crosses with Holstein Friesian and jersey dairy cows. The overall mean ± standard error of Age at First Service (AFS), Age at First Calving (AFC), Number of Services Per conception (NSP), Calving Interval (CI), Days Open (DO), Conception Rate (CR) and Replacement Rate (RR) were 29.2 ± 0.2 months, 39.8 ± 0.2 months, 1.76 ± 0.4, 13.2 ± 0.3 months, 94.3 ± 4.3 days, 75.0 ± 1.3%, and 28.4 ± 0.3%, respectively. At 60 and 90 days, the odds ratio of the Non Return Rate (NRR) was 0.22 and 0.96, respectively. The breeds (sire and dam) and birth period had a significant (P<0.001) influence on AFS and AFC, whereas season and dam parity had a significant influence on CI and DO. Inconsistent management in feeding, heat detection, inseminator skills, insemination time, health, and other husbandry practices may result in extended periods of AFS, AFC, CI, and DO. To improve the reproductive performance of Horro and their crosses with Holstein Friesian and Jersey dairy cows in Ethiopia's subhumid environments, we should focus on increasing management factors.

Keywords: Horro cattle; Crosses; Conception rate; Replacement rate; Subhumid; Tropical; Ethiopia

INTRODUCTION

The continent of Africa's largest population of livestock is thought to reside in Ethiopia. About 70 million cattle are considered in the country overall, and according to the CSA neither hybrid nor exotic breeds make up more than 2% of the total cattle population. According to the FAO and IGAD cattle industry made for up to 47% of the agricultural GDP, approximately 20% of the overall GDP, and 20% of the country's foreign exchange revenue in 2017 [1,2]. In dairy farms, reproduction is important because it boosts milk output by lowering cow elimination rates and improving breeding success rates [3]. Production, herd replacement, and overall profitability were thus critical components for reproduction in dairy farming [4]. The ideal breeding method and lifetime production in herds, on the other hand, depend on an estrus detection system, the proper time of insemination, proper feeding, and health care practices [5]. The most likely management factors that accounted for the longer period of AFS, AFC, CI, and DO were the poor efficiency of estrus detection and expression [6]. Dairy cattle performance was influenced by breed, nutrition, diseases, breeding, and management practices. According to Duguma the

Correspondence to: Habtamu Abera Goshu, Department of Genetics and Molecular Breeding, Bio and Emerging Technology Institute, Addis Ababa, Ethiopia; E-mail: habtamu2016@yahoo.com

Received: 29-Sep-2022, Manuscript No. HGCR-22-18190; **Editor assigned:** 03-Oct-2022, PreQC No. HGCR-22-18190 (PQ); **Reviewed:** 17-Oct-2022, QC No. HGCR-22-18190; **Revised:** 27-Jan-2023, Manuscript No. HGCR-22-18190 (R); **Published:** 03-Feb-2023, DOI: 10.35248/2161-1041.23.12.237

Citation: Jalata B, Goshu HA, Mediksa T, Bekele D, Aliye M (2023) Horro and their Crossbred Dairy Cow's Reproductive Performance in Ethiopia Subhumid Tropical Environments. Hereditary Genet. 12:237.

reproductive performance of crossbred cows was better and lower due to delayed AFS, late AFC, long CI, shorter LL, low daily and LMY, and high NSC. On the other hand, management inconsistency and variability of climatic variables across the year and seasons appear to have a significant influence on cow reproductive efficiency [7]. Hammoud, et al., demonstrated that the sire of the cow, management systems, and appropriate environmental conditions all have a significant influence on the reproductive efficiency of Friesian cows in semiarid Egypt. Improvements in management and parent selection based on breeding value would improve the reproductive performance of Jersey cows [8]. Ethiopian researchers reported on the reproductive efficiency of both indigenous and crossbred cows. Selection, environmental variability, and the use of multiple sires all contribute to the farm's genetic diversity. Comprehensive and up to date information on the breed's performance in terms of reproduction, growth, and milk yields, as well as the factors influencing those performances, is critical for long term breed improvement and conservation efforts [9,10]. As a result, regular evaluation of dairy cow reproductive potential at the research center is critical for the program's future breeding. According to many researchers, Horro and its crosses with Holstein Friesian and Jersey dairy cows have had reproductive significant success, but limited small data records [11,12]. The replacement rate and non-return rate at 60 and 90 days, however, have not been reported. This study aimed to determine the reproductive performance and factors influencing the reproductive performance of Horro and their crosses with Holstein Friesian and jersey dairy cows in Ethiopia's subhumid tropical environments.

MATERIALS AND METHODS

Description of study area

The research was carried out at the Bako agricultural research center, which is located in the Oromia regional state's West Shoa Zone, about 250 kilometers from Addis Ababa, Ethiopia's capital city. The center receives 1200 mm of annual rainfall in a bimodal distribution, with 80% of it falling between May and September. The center is 8 kilometers from Bako town, at an elevation of 1650 meters above sea level, and is located between 09°6'N latitude and 37°09'E longitude. The average relative humidity in the area was 59%, with mean minimum and maximum temperatures of 13.5 and 27°C, respectively.

Herd management

Colostrum was fed to the calves for the first five days. Then, at birth, they were separated from their dams and fed from buckets. A total of 227 liters of milk were fed to each calf, along with a concentrate mix (49.5% girded maize, 49.5% noug seed cake, and 1% salt) until weaning (three months), after which both calves (male and female) were kept indoors (day and night) in individual pens until six months of age, except for about two hours of exercise in a nearby paddock every day. After six months of age, the calves were kept on natural pastures for approximately eight hours a day, supplemented with silage or hay adlibitum during the night, and kept as a group (male and female separately), with concentrate supplemented to heifer calves only when available.

The farm's feeding system is primarily based on grazing natural pastures (*Cynodon* spp. and *Hyparrhenia* spp.) for approximately eight hours per day (8 AM to 5 PM). The pastures are not fertilized or irrigated. Depending on the availability of hay and silage and the condition of grazing, hay (Rhode's grass and natural pasture) or silage (Rhode's grass and Maize silage) is provided at night. Concentrate supplementation is only available to milking cows at the time of milking and to pregnant cows during the third trimester of pregnancy. While being milked, cows are given a concentrate made of maize grain and noug cake (*Guizotia abyssinica*). Each lactating cow received a daily concentrate supplement of about 0.5 kg prior to milking. The amount is determined by the amount of milk produced by each cow. Cows are milked by hand twice a day, mated naturally and Artificially (AI), and housed in a loose system.

Herd breeding system

At the Bako agricultural research center, heifers were bred at least two years old when they reached a body weight of 200 kg. Heat detection was done visually every day from 06:00 to 08:00 a.m. and 17:00 to 18:00 p.m. by a trained inseminator, as well as during grazing time by the herdsmen. Cows and heifers in heat were either bred naturally (using a local or crossbred bull) or artificially inseminated with frozen sperm (Holstein Friesian and Jersey) purchased from the Kality national artificial insemination center within 24 hours of heat.

Data source

From 1980 to 2019, reproductive data on Horro and crosses with Holstein Friesian (HF) and Horro X Jersey (HJ) cows were collected at Bako agricultural research center for the first service, services per conception, date of first calving, day open, and calving interval. The data was collected with the utmost care for its quality from records that began with the identification number for all reproductive parameters studied. Meanwhile, only cows with complete information were considered for the study.

Data preparation and statistical analysis

The data was collected from 1980 to 2019 and entered into Microsoft Excel software for a preliminary assessment of data distribution. The data was classified into several categories for statistical analysis. Pure Horro, pure Jersey, pure Holstein-Friesian, and crosses of Jersey X Horro and Holstein Friesian X Horro (50%) were the sire genotypes. The dam genotypes were pure Horro, Jersey X Horro cross, and Holstein Friesian X Horro cross (50%). Parity was classified as 1, 2, 3, 4,5,6 and ≥ 7 parities above 7 were included and considered as ≥ 7. The calving periods were classified into four years (1980-1989), (1990-1999), (2000-2009), and (2010-2019). Age was classified into twelve age classes in each repeated ten months (26-36), (37-46), (47-56), (57-66), (67-76), (77-86), (87-96), (97-106), (107-116), (117-126), (127-136) and 12>137 months. Based on the metrological data, the seasons were grouped in to three November to February (dry season), March to June (short rainy season), and July to October (long rainy season). Records of unknown sire and dam were removed. Finally, 915 for AFC and AFS, 3152 for NSP, CI, DO, CR, NRR and RR data were used for analysis.

The general linear model procedures in the Statistical Analysis System (SAS) 9.3 were used to analyze the data. The logistic regression model was used to determine the presence of any significant differences. They were checked by using TUKEY-Kramer multiple comparison tests at P<0.05. The non-return rate at 90 days and 60 days was coded as 1 if the cow was conceived and 0 if the cow was not conceived at 90 or 60 days. The reproductive traits of Age at First Service (AFS), Age at First Calving (AFC), Number of Services per Conception (NSP), Calving Interval (CI), Days Open (DO), Conception Rate (CR), Non-Return Rate (NRR) and Replacement Rate (RR) were considered as dependent variables, whereas period, season, sire, dam, parity and age of the dam were taken as independent variables. Interaction effects of fixed factors (year by parity, year by sex, year by breed, parity by sex, parity by breed, sex by breed) were tested and had no significant effect on the traits studied. Hence, all interaction effects were excluded from the final model. The following statistical models were used for this study:

Model 1: Age at First Service (AFS) and Age at First Calving (AFC).

$Y_{ijklm}=\mu+S_i+D_j+P_k+Z_l+e_{ijklm}$

Where:

Y_{ijklm}=mth record (AFC,AFS) of ith Sire, jth Dam, kth birth period, lth season of the dam.

μ=overall mean

S_i=fixed effect of ith sire breed (i=Horro, Jersey, Holstein Friesian, crosses (Jersey X Horro and Holstein Friesian X Horro).

D_j=effect of jth dam breed (j=Horro, cross (Jersey X Horro and Holstein Friesian XHorro).

P_k=calving Period (j=1980-1989, 1990-1999, 2000-2009, 2010-2019).

Z_l=the fixed effect of lth season (k=Nov-Feb, Mar-Jun and Jul-Oct).

e_{ijklm}=residual error

Model 2: Calving Interval (CI) and day open.

$Y_{ijklmnz}=\mu+S_i+D_j+Y_k+C_l+P_m+A_n+e_{ijklmnz}$

Where: $Y_{ijkllmnz}$=zth record (CI,DO) of ith sire, jth dam, kth period of calving, lth season of calving, mth parity of the dam, nth age class.

μ=overall mean

S_i=fixed effect of ith sire breed (Horro, Jersey, Holstein Friesian, crosses (Jersey X Horro and Holstein Friesian X Horro).

D_j=fixed effect of jth dam breed (j=Horro, crosses (Jersey X Horro and Holstein Friesian X Horro).

Y_k=fixed effect of kth calving period (k=1,2,3,4).

C_l=the fixed effect of lth season (l=1,2,3).

P_m=effect of mth of parity (m=1,2,3,4,5,6 and above ≥ 7).

A_n=effect of nth of age of dam (n=1,2,3,4,5,6,7,8,9,10,11 and 12).

$e_{ijklmnz}$=random residual error term.

Model 3: Number of Services per Conception (NSP).

$Y_{ijklmnz}=\mu+S_i+D_j+Y_k+C_l+P_m+A_n+e_{ijklmnz}$

Where: $Y_{ijkllmnz}$=zth record (NSP) of ith sire, jth dam, kth period of calving, lth season of calving, mth parity of the dam, nth age class.

μ=overall mean

S_i=fixed effect of ith sire breed (i=Horro, Jersey, Holstein Friesian, cross (Jersey X Horro and Holstein Friesian X Horro).

D_j=fixed effect of jth dam breed (j=Horro, cross (Jersey X Horro and Holstein Friesian X Horro).

Y_k=fixed effect of kth calving period (k=1,2,3,4).

C_l=fixed effect of lth season (l=1,2,3).

P_m=effect of mth of parity (m=1,2,3,4,5,6 and above ≥ 7).

A_n=effect of nth of age of dam (n=1,2,3,4,5,6,7,8,9,10,11 and 12).

$e_{ijklmnz}$=random error

Model 4: Non-Return Rate (NRR), Conception Rate (CR), and Replacement Rate (RR).

$Y_{ijklmnz}=\mu+S_i+D_j+Y_k+C_l+P_m+A_n+e_{ijklmnz}$

Where: $Y_{ijkllmnz}$=the zth record (CR,NRR,RR) of ith sire, jth dam, kth period of calving, lth season of calving, mth parity of the dam, nth age class.

μ=overall mean

S_i=fixed effect of ith sire breed (i=Horro, Jersey, Holstein Friesian, cross (Jersey X Horro and Holstein Friesian X Horro).

D_j=fixed effect of jth dam breed (j=Horro, cross (Jersey X Horro and Holstein Friesian X Horro).

Y_k=fixed effect of kth calving period (k=1,2,3,4).

C_l=fixed effect of lth season (l=1,2,3).

P_m=effect of mth on parity (m=1,2,3,4,5,6, and above ≥ 7).

A_n=effect of nth of age of dam (n =1,2,3,4,5,6,7,8,9,10,11, and 12).

$e_{ijklmnz}$=random error

The Logistic regression model was used to examine the relationship between independent variables sire, dam, period, season, parity, age, and log odds of the binary outcome variable (NRR at 60 and 90 days). The specific form of the logistic regression model as described by Hosmer and Lemeshow is:

$$P(x) = \frac{e^{B0+B1x}}{1+e^{B0+B1x}}$$

Thus P(x) is linear in its parameters, with a variable y/x=P(x)+e

If y=1, then e=1-P(x) with probability P(x),

If y=0, then e=-P(x) with probability 1-P(x)

Non-return rate=1/1+OR the non-return rate was conceived at 60 or 901 and if not conceived, Odds Ratio (OR) is the rate of odds for x=1 to odds for x=0. Thus, the odds of the outcome being present among cows with x=1

RESULTS AND DISCUSSION

Age at First Service (AFS) and Age at First Calving (AFC)

The breeds (sire and dam) and birth period significantly (P<0.001) influenced AFS and AFC, while the season of the year was not significant. According to Hammoud, et al., sires had a highly significant impact on AFC. Cows calved during the period of 1980-1989, which had longer than the others. The major impact of birth period on AFS and AFC may result from climate changes and variations in management from year to year. Getahun, et al., and Tesfa, et al., presented similar findings, demonstrating that birth period had a significant effect on AFS and AFC. AFS and AFC's overall means were 29.2 ± 0.2 and 39.8 ± 0.2 months, respectively. Although AFS and AFC for Fogera cattle bred at Andassa livestock research center were 38.9 ± 0.72 months and 51.8 ± 0.72 months, respectively [13]. Thus far, research has been reported that AFS for local and crossbred 26.8 and 37.4 months at Holeta agricultural research center and 27 and 37 months for Holstein Friesian dairy cows at Alage dairy farm. Similarly, Tadesse, et al., reported that AFC of Holstein Friesian dairy cows in Ethiopia was 39.2 ± 7.5 months. The mean AFC obtained in this study is higher than 24.8 ± 6.6 months that was reported for Holstein Friesian/zebu cattle crossbred 27.5 and 25.6 months in Debre Birhan, Jimma, and Sebeta and Dire-Dewa for Holstein Friesian crosses with indigenous breeds. Indeed, these results were lower than reported by Hundie, et al., who found that the average Age at First Service on station and on farm for local Horro and Horro-Jersey F1 crosses were 48.85 months and 33.25 months in and around Horro Guduru livestock production and research center. In disagreement with these findings, the overall AFS for local and crossbreed were 26.4 ± 0.8 and 35.7 ± 0.81 months, respectively at Holeta agricultural research center and AFS and AFC for Holstein Friesian × Arsi and Holstein Friesian × Boran cattle at Agarfa agricultural technical and vocational education training were 32.05 ± 0.57 and 41.16 ± 0.56 months. These results may be explained by the prolonged AFC in the present study compared to literature results could be attributed to factors such as poor nutrition and management practices including poor heat detection at the time of mating the heifers. On the other hand, a significant reduction in AFS and AFC from 1980 to 2019 indicated a progressive improvement in management. Similarly, the large variation of AFC attributed to the management level provided to individual cows at the farm level (Table 1). In comparison, the overall least squares means for AFS and AFC for Jersey cattle raised under semi-intensive management in Ethiopia were 22.93 ± 0.22 months and 32.95 ± 0.22 months. Nonetheless, under smallholder conditions in and around Zeway, Ethiopia, the current AFC result is slightly higher than crossbred heifers in the urban (31.9 months) and rural (32.4 months) [14]. In contrast to these findings, the AFC of pure Jersey is 29.9 0.17 months [15]. The optimal calving age for maximum lifetime profit ranged from 22.5 to 23.5 months [16].

Table 1: The effect of sire, dam, birth period, and birth season on age at first service and age at first calving of LSM ± se.

Traits		**N**	**AFS (months)**	**AFC (months)**
Overall	**Mean**	915	29.2 ± 0.17	39.8 ± 0.18
Sire breeds	**P-values**		***	***
Holstein Friesian		67	28.5 ± 0.37^{b}	40.1 ± 0.38^{b}
Jersey		48	28.4 ± 0.20^{b}	37.6 ± 0.38^{c}
F_1 (Holstein Friesian X Horro)		44	29.9 ± 0.44^{a}	40.9 ± 0.45^{ab}
F_1 (Jeresy X Horro)		50	29.2 ± 0.60^{ab}	39.2 ± 0.62^{bc}
Horro		315	30.2 ± 0.28^{a}	41.2 ± 0.28^{a}
Dam breed	**P-values**		***	***

Horro		745	32.1 ± 0.22ᵃ	43.3 ± 0.22ᵇ
F_1 (Holstein Friesian X Horro)		86	27.67 ± 0.4ᶜ	37.6 ± 0.42ᵈ
F_1 (Jeresy X Horro)		84	27.9 ± 0.52ᵇ	38.5 ± 0.53ᶜ
Period	**P-values**		***	***
1980-89		164	31.5 ± 0.20ᵃ	41.3 ± 0.31ᵃ
1990-99		230	30.2 ± 0.26ᵃᵇ	40.8 ± 0.25ᵇ
2000-09		435	28.4 ± 0.22ᵇ	39.9 ± 0.22ᵇ
2010-19		86	26.7 ± 0.23ᶜ	37.2 ± 0.23ᶜ
Season	**P-values**		NS	NS
Nov-Feb		304	29.3 ± 0.23ᵃ	39.7 ± 0.22ᵃ
Mar-Jun		240	29.0 ± 0.22ᵃᵇ	39.6 ± 0.51ᵃ
Jul-Oct		371	29.3 ± 0.22ᵃᵇ	40.0 ± 0.20ᵃ

Note: N: Number of observations; AFS: Age at First Service; AFC: Age at First Calving; ***P<0.0001; NS: Non-Significant

Number of Service preconceptions (NSC

At Bako agricultural research center, the overall mean value for NSC by natural and AI mating is 1.76 (Table 4). The NSC for Holstein Friesian at Alage dairy farm was 1.92 ± 0.48 and 1.8 ± 0.03 for Barona and Friesian crossbred at Holeta agricultural research center. When comparing different sires, dams sired by Holstein Friesian crosses (F1) had lower (1.57 ± 0.09) NSC than Jersey crosses (2.09 ± 0.14). The sire effect of pure Horro and the two pure exotic breeds, on the other hand, was similar and non-significant, whereas the two crosses performed significantly better than the other groups on NSC. According to Kebede, et al. NSC is less natural mating than AI. In compared to these findings, sire had a significant influence on NSC. The obtained result was lower than the findings of Hundie, et al. who reported that the overall mean value of Horro and Horro-Jersey was 2.1 ± 1.09 and 1.7 ± 0.94, respectively. The finding in this study was higher when compared to the study conducted by who showed that the overall NSC for local and crossbred dairy cows was 1.6 in Bako agricultural research center. On the other hand, Kebede, et al. reported that the number of services per conception for Horro (zebu), Horro x Friesian, and Horro x Jersey were 2, 1.97 and 1.92, respectively. Furthermore, various scholars have been reported that the year has significant effect on NSC. The NSC for Horro cows served by the bull and artificial insemination was 1.76 and 2.09, respectively. Calving period and calving season had a highly significant (P<0.01) effect on NSC and lower in March to June than November to February. These differences could be due to the reproductive status of the animal, different breeding practices, feeding, and management from year to year. Consistent with the results, service per conception is significantly influenced by parity and herd of animals. In the number of services per conception there are no significant differences among dam genotypes. In agreement with these results Kebede, et al., reported that Horro X Jersey crosses had required less number of services per conception than the other breeds. Opposite to the report of Kebede, et al. the current study revealed that local Horro required less NSC than the F1 Jersey x Horro and F1 FriesianxHorro cows. On the other hand, NSC was significantly higher in parity 1st to 3rd and lower from the 4th to 7th parity. Similarly, NSC was higher in the 1st and 2nd parity while lower in the 4th and 5th parity. On the other hand, the results revealed that cow services during the years of 1990-1999 required lower (1.5) NSC than cow services during the years of 1980-89 (1.86), 2000-2009 (1.82), and 2010-2019 (1.82). These results may be explained that inconsistent management in feeding, heat detection, skill of inseminator, time of insemination, semen quality, and other husbandry practices [17].

Calving Interval (CI) and Days Open (DO)

For local Horro and their crosses with Holstein Friesian and Jersey cows, the overall square mean of CI and DO was 13.20 months and 94.26 days. Comparable to these results, Dabi reported that the overall mean of DO and CI for Horro cows were 13.31 months and 88.13 days, respectively, based on data obtained from the Bako agricultural research center. Similarly reported mean intervals from calving to first heat of 72.4 days (range 15-253) and calving to conception of 119.2 days (range 57-317) for Horro cows and intervals from calving to conception of 123 days (range 66-277) for Horro X Friesian cows. Indeed, the DO and CI for Borana X Holstein Friesian cows at Holeta agricultural research canter were 476 and 197 days, respectively and for Sheko cattle breeds were 248.3 ± 6 days and 17.4 ± 0.2 months [18-20]. Season, dam, parity, and agro ecological zones all have a significant effect on the CI and DO of traditionally managed Sheko cattle in southwest Ethiopia [21]. According to Peters, the CI and DO of Horro and their crosses with Holstein Friesian and Jersey cows obtained in this study required more time to achieve the recommended DO ranging from 80-85 days and a CI of 12 months. Following these results, postulated that management efforts should be made to reduce the longer CI associated with differences in management practices. If a Calving Interval of 12 months is to be achieved, days open should not exceed 80-85 days, which are influenced by nutrition, season, milk yield, parity, suckling, and uterine involution. Differences in nutritional and reproductive management among dairy production may be attributed to differences in dairy cow reproductive performance. Various researchers have found that the discrepancy in DO could be attributed to dairy cow management. Nevertheless, Beneberu, et al. explained that reproductive differences are caused by breed, genetic potential, seasonal availability and quality of feed, climate, heat detection, the skill of AI technicians, and the quality of semen used for insemination. Dam, parity and damage all had a significant (P<0.05) effect on CI and DO. The highest values in younger cows could be due to the dam's fertility, as well as the high nutrient requirements for growth, production, and reproduction. The CI and DO were significantly higher in the second and third parties and lower in the fourth to seventh parties. The current report's finding that parity has a significant effect on DO and CI is consistent with the findings of Beneberu, et al. for Jersey cattle, for smallholder dairy cattle, for crossbred dairy cattle, for pure Jersey dairy cattle and Gojam, et al. for crossbred dairy cattle. The effect of sire and calving season on CI and DO was nonsignificant. According to these reports, the calving season has a significant effect on CI but has no effect on DO. Tadesse, et al. revealed that parity and calving season have a significant influence on CI and DO, which is consistent with these findings. The average CI for intensive dairy farms in Central Ethiopia was 483.2 days [22]. Moreover, Mezgebe, et al. observed that cows with a shorter calving interval give birth earlier in the calving season, making cows conceive more easily and increasing calves growth performance (Table 2).

Table 2: The effect of sire, dam, calving period/season, parity, and damage on the number of services preconceptions, calving interval, and days of open LSM ± se.

Traits		N	NSC	CI (months)	DO (days)
Overall	**Mean**	3152	1.76 ± 0.0	13.2 ± 0.3	94.29 ± 4.3
Sire	**P-values**		**	NS	NS
Holstein Friesian		67	1.79 ± 0.1^{ab}	12.9 ± 0.3^{a}	96.7 ± 10.1^{ab}
Jersey		48	1.64 ± 0.8^{b}	13.1 ± 0.3^{a}	91.6 ± 5.6^{ab}
F_1 (Holstein Friesian X Horro)		44	1.57 ± 0.1^{c}	13.2 ± 0.4^{a}	100.5 ± 6.4^{a}
F_1 (Jersey X Horro)		50	2.1 ± 0.1^{a}	13.6 ± 0.5^{a}	83.9 ± 8.2^{b}
Horro		315	1.7 ± 0.1^{b}	13.1 ± 0.3^{a}	98.7 ± 5.1^{a}
Dam	**P- values**		**	***	***
Horro		2771	1.7 ± 0.1^{ab}	13.9 ± 0.3^{b}	100.5 ± 4.5^{a}
F_1 (Holstein Friesian X Horro)		180	1.96 ± 0.1^{b}	13.2 ± 0.4^{ab}	82.5 ± 6.4^{b}
F_1 (Jersey X Horro)		201	1.6 ± 0.1^{a}	12.3 ± 0.4^{a}	99.9 ± 7.6^{ab}
Calving period	**P- values**		***	**	NS
1980-89		291	1.86 ± 0.1^{bc}	13.4 ± 0.6^{abc}	94.6 ± 5.5^{a}
1990-99		459	1.6 ± 0.2^{a}	12.9 ± 0.5^{ab}	92.9 ± 4.7^{a}
2000-09		1633	1.8 ± 0.1^{ab}	12.7 ± 0.5^{a}	93.5 ± 4.1^{a}
2010-09		769	1.8 ± 0.1^{ab}	13.0 ± 0.5^{b}	96.1 ± 4.6^{a}

Calving season	**P-values**		***	NS	NS
Nov-Feb		972	1.8 ± 0.05^{b}	13.1 ± 0.3^{a}	96.8 ± 4.6^{a}
Mar-Jun		936	1.7 ± 0.1^{a}	13.3 ± 0.5^{a}	94.2 ± 6.1^{a}
Jul-Oct		1244	1.78 ± 0.1^{ab}	13.2 ± 0.3^{a}	93.3 ± 9.1^{a}
Parity	**P- values**		**	***	***
1		914	2.1 ± 0.2^{a}	_	_
2		635	2.1 ± 0.1^{a}	15.5 ± 0.3^{a}	118.7 ± 5.8^{a}
3		485	1.95 ± 0.1^{ab}	14.5 ± 0.6^{a}	106.9 ± 5.5^{ab}
4		357	1.72 ± 0.2^{b}	13.5 ± 0.6^{ab}	98.6 ± 9.5^{b}
5		265	1.59 ± 0.1^{ab}	12.8 ± 0.6^{b}	86.4 ± 5.8^{bc}
6		194	1.62 ± 0.2^{ab}	11.9 ± 0.6b^{c}	83.7 ± 6.3^{bc}
≥ 7		302	1.30 ± 0.2^{c}	10.9 ± 0.4^{c}	71.5 ± 7.6^{c}
Age class (months)	**P-values**		***	***	***
26-36		140	1.3 ± 0.2^{df}	10.9 ± 2.5^{cdf}	105.6 ± 43.3^{abcd}
37-46		526	1.3 ± 0.2^{d}	10.7 ± 0.5^{d}	68.2 ± 8.7^{cd}
47-56		556	1.3 ± 0.2^{d}	10.9 ± 0.6^{d}	64.1 ± 5.6^{d}
57-66		419	1.4 ± 0.1^{cd}	11.1 ± 0.5^{cd}	71.6 ± 4.3
67-76		341	1.5 ± 0.1^{c}	12.5 ± 0.3^{c}	83.7 ± 4.4^{bc}
77-86		269	1.7 ± 0.1^{bc}	13.2 ± 0.2^{bc}	88.2 ± 8.8^{bc}
87-96		232	1.7 ± 0.1^{bc}	13.6 ± 0.6^{bc}	93.3 ± 4.8^{b}
97-106		183	1.9 ± 0.2^{bc}	13.7 ± 0.6^{bc}	96.7 ± 5.9^{b}
107-116		161	1.97 ± 0.2^{b}	14.7 ± 0.5^{b}	108.0 ± 4.2^{ab}
117-126		120	2.3 ± 0.2^{a}	14.9 ± 0.7^{ab}	112.2 ± 7.4^{ab}
127-136		82	2.4 ± 0.2^{a}	15.4 ± 0.4^{a}	119.4 ± 6.7^{a}
≥ 137		122	2.3 ± 0.2^{a}	15.8 ± 0.4^{a}	122.4 ± 7.6^{a}

Note: NSP: Number of Service Preconception; CI: Calving Interval; DO: Days Open; ***P<0.0001; **P<0.001; *P<0.05; NS: Non-Significant

Conception Rate (CR)

Table 3 shows the CR for local and crossbred cows at Bako agricultural research center. The overall mean CR values were 75% local and crossbred cows. The higher these results CR (81%) for Holstein Friesian dairy cows at Alage dairy farm. The effect of sire, dam, period, season, parity, and dam age on CR was significant (P<0.05). The results showed that animals mated by a Holstein Friesian x Horro sire had a higher conception rate (80.7 ± 2.9%) than animals mated by a pure Jersey sire (78.5 ± 2.4%), a pure Horro sire (74.5 ± 1.8%), a pure Holstein Friesian sire (73.3 ± 2.4%) and a Jersey-Horro sire (67.7 ± 3.8%), respectively. In Addis Ababa, however, the rate of successful conception after Artificial Insemination (AI) was 66.1%. CR was higher than, who reported 60.4% in Southern region of Ethiopia. Furthermore, CR is comprised of 73% smallholder dairy cattle and 48.3% Eastern Showa zone of the Oromiya region. In agreement with these results, reported that the conception to first service, pregnancy, and calving rates across crossbred dairy cows in Ethiopia's Eastern Lowlands were 72.8%, 45.9% and 63.4%, respectively.

Replacement Rate (RR)

The overall RR determined in total pregnancy at Bako agricultural research center of dairy farm has been 28.4 % for all genetic groups (Table 3). Sire calves from pure Jersey (30%) and their crosses with Horro (30%) genetic groups have a higher RR than pure Horro, pure Holstein Friesian, and Holstein Friesian crosses with Horro genetic groups. Female RRs in Holstein Friesian cattle are 70% based on female births. Parity had a significant ($p<0.05$) effect on RR, with the first four parities having a higher RR than the rest; this could be because the animal is matured and has adapted to its environment at this stage. Consistent with these results, a lower RR in some parities may be due to the combined effect of high mortality, culling, and high male birth. The RR was higher from 2010 to 2019 than the others period. Similarly, parity and year of calving have a significant impact on RR. RR, on the other hand, is influenced by abnormal birth rates, sex ratio, postnatal mortality, and heifer culling from birth to the age of first calving. Furthermore, the RR for female calves and total calves was 72.64 and 37.55 %, respectively, in female Sahiwal cows up to the age of first calving. The results of this study were lower than those of Upadhyay, et al. in Sahiwal females, but higher than those of in Holstein Friesian cattle (29%) at Holeta bull dam station. This variation could be attributed to breed differences, environmental adaptation, and sire fertility [23-26].

Table 3: The effect of sire, dam, and birth period/season on conception rate and replacement rate, LSM ± se.

Traits		N	CR (%)	RR (%)
Overall	**Mean**	3152	75.0 ± 1.3	28.4 ± 0.3
Sire	**P-values**		**	***
Holstein Friesian		67	73.34 ± 2.44^{bc}	26.76 ± 0.57^{c}
Jersey		48	78.50 ± 2.36^{ab}	30.01 ± 0.82^{ab}
F_1 (Holstein Friesian X Horro)		44	80.68 ± 2.86^{a}	27.52 ± 0.63^{b}
F_1 (Jersey X Horro)		50	67.72 ± 3.81^{c}	30.01 ± 0.57^{a}
Horro		315	74.50 ± 1.83^{b}	26.91 ± 0.40^{bc}
Dam	**P-values**		*	NS
Horro		2771	77. 82 ± 1.46^{a}	28.75 ± 0.31^{a}
F_1 (Holstein Friesian X Horro)		180	71.28 ± 2.70^{b}	28.87 ± 0.58^{a}
F_1 (Jersey X Horro)		201	75.81 ± 3.38^{ab}	27.61 ± 0.73^{a}
Calving period	**P-values**		***	***
1980-89		291	71.48 ± 2.56^{bc}	26.52 ± 0.44^{b}
1990-99		459	81.19 ± 2.42^{a}	24.75 ± 0.37^{c}
2000-09		1633	73.73 ± 1.28^{b}	25.65 ± 0.32^{bc}
2010-19		769	74.47 ± 1.23^{bc}	36.75 ± 0.33^{a}
Calving season	**P-values**		***	Ns
Nov-Feb		972	72.59 ± 1.22^{abc}	28.32 ± 0.39^{a}
Mar-Jul		936	77.67 ± 1.27^{a}	28.25 ± 0.32^{a}
Jun-Oct		1244	74.63 ± 1.25^{ab}	28.67 ± 0.31^{a}

Parity	**P-values**		**	***
1		914	65.20 ± 3.40^{c}	34.41 ± 0.74^{a}
2		635	65.55 ± 2.99^{bc}	32.05 ± 0.68^{b}
3		485	67.82 ± 2.67^{bc}	30.13 ± 0.54^{bc}
4		357	74.67 ± 2.9^{3b}	28.60 ± 0.66^{c}
5		265	80.69 ± 3.09^{ab}	26.76 ± 0.77^{d}
6		194	80.87 ± 3.50^{ab}	24.32 ± 0.62^{df}
≥ 7		302	90.02 ± 4.05^{a}	22.17 ± 0.88^{f}
Age class (months)	**P-values**		**	***
26-36		140	88.96 ± 4.12^{a}	25.64 ± 0.90^{f}
37-46		526	87.70 ± 3.57^{a}	25.23 ± 0.98^{df}
47-56		556	87.85 ± 4.32^{a}	26.07 ± 0.62^{d}
57-66		419	85.42 ± 4.13^{ab}	27.76 ± 0.58^{cd}
67-76		341	82.53 ± 2.96^{bc}	27.32 ± 0.85^{c}
77-86		269	77.83 ± 2.89^{bc}	28.30 ± 0.53^{c}
87-96		232	75.84 ± 2.93^{b}	$29.45 \pm 0.56b^{c}$
97-106		183	70.48 ± 3.18^{cd}	30.74 ± 0.89^{ab}
107-116		161	69.27 ± 4.50^{d}	31.62 ± 0.73^{a}
117-126		120	60.83 ± 5.19^{df}	30.27 ± 0.93^{abc}
127-136		82	55.14 ± 5.91^{f}	30.82 ± 1.11^{ab}
≥ 137		122	58.37 ± 5.80^{f}	27.42 ± 1.08^{c}

Note: CR: Conception Rate; RR: Replacement Rate; ***P<0.0001; **P<0.001; Ns: Non-significant

Non-Return Rate (NRR-60 and 90 days

At Bako agricultural research center, the non-return rate at 60 days has a worse performance than the non-return rate at 90 days (Table 4). At 60 days, there was a low odds ratio and thus a low conception rate and more conceptions occurred as more services were used up to 90 days. At 60 and 90 days, the odds ratio of Non-Return Rate (NRR) is 0.22 and 0.96, respectively. As a result, the odds ratio of NRR at 90 days outperformed the odd ratio of NRR at 60 days in terms of performance efficiency. On the other hand, discovered that the first service NRR in the retrospective and field follow-up studies was 86.6% and 48.2%, respectively. Furthermore, a retrospective study by Tadesse, et al. revealed that the NRR at first insemination was 86.55%. The effects of sire, calving season, and dam age on NRR at 60 and 90 days were significant (P<0.05). Dam parity and dam breeds, on the other hand, had no effect on NRR at 60 and 90 days. Furthermore, timing of insemination, feeding management, heat detection efficiency, early embryonic mortality, and the presence of an ovarian cyst are all known to have a negative impact on NRR. When the sires were compared, higher values of the odds ratio of NRR were recorded for Holstein Friesian. At 60 days, Friesian X Horro crosses were 0.54 and Jersey-Horro crosses were 1.45. Similarly, Ali, et al., found that the odds ratio of conception in high producing cows was greater than one (probability=0.56) after the first service and increased with 1.63 (probability=0.65) after the third service [27-29].

Table 4: The effect of sire, dam, damage caving period and season on odds ratio of non-return rate at 60 and 90 days.

Traits	NRR (60) days			NRR (90) days		
	N	OR	Se	N	OR	Se
Sire		***			**	
Holstein Friesian	28	0.22	0.2351	56	0.81	0.176
Jersey	29	0.31	-	55	0.98	-
F1 (Holstein Friesian X Horro)	28	0.54	0.2854	27	0.51	0.2418
F1 (Jersey X Horro)	21	0.47	0.5723	32	1.45	0.3597
Horro	231	0.19	0.1828	565	0.99	0.1313
Dam		Ns			Ns	
Horro	296	0.33	0.5151	650	0.89	0.3885
F1 (Holstein Friesian X Horro)	21	0.3	0.5538	47	5.88	0.4209
F1 (Jersey X Horro)	25	0.3	-	42	1.27	-
Calving period		Ns			**	
1	29	0.23	0.192	49	0.57	0.1453
2	36	0.16	0.1528	124	2.21	0.1038
3	187	0.22	0.1095	380	0.83	0.0794
4	88	0.29	-	187	1.11	-
Calving season		***			*	
Nov-Feb	80	0.19	0.0961	219	0.97	0.0675
Mar-Jul	89	0.17	0.0933	243	1.2	0.0664
Jun-Oct	171	0.31	-	278	0.82	-
Parity		Ns			Ns	
1	8	-4	1.0566	3	0.75	0.8511
2	73	0.15	0.3527	233	1.37	0.2752
3	74	0.22	0.3077	150	0.82	0.2466
4	50	0.19	0.2821	118	0.98	0.2255
5	55	0.35	0.2689	75	0.65	0.2232
6	32	0.25	0.294	61	0.85	0.2367
≥ 7	48	0.14	0.3488	100	0.98	0.2754
Age class (months)		**			Ns	

26-36	7	-1.75	1.1859	1	0.25	1.2493
37-46	2	0.05	0.7762	19	3.17	0.3672
47-56	41	0.22	0.3389	100	1.45	0.2612
57-66	57	0.19	0.3043	148	1.22	0.2391
67-76	46	0.18	0.2937	114	1.01	0.2277
77-86	40	0.21	0.2797	81	0.76	0.2229
87-96	38	0.24	0.2809	66	0.66	0.2254
97-106	36	0.32	0.2988	59	0.91	0.2436
107-116	26	0.24	0.3309	40	0.49	0.2747
117-126	17	0.2	0.4032	48	2	0.3107
127-136	9	0.14	0.5127	29	1.21	0.3714
≥ 137	21	0.26	-	35	0.67	-

Note: OR: Odd Ratio; NRR: Non-Return Rate; $^{***}P<0.0001$; $^{**}P<0.001$; $^{*}P<0.05$; Ns: Non-significant

CONCLUSION

Given the foregoing, the effects of sire genetic group on conception rate and non-return rate were studied at Bako agricultural research center. The findings revealed that the sire genetic group had a significant effect on the local and crossbred conception rates and non-return rates. The dam genetic group influenced the conception rate but had no effect on non-return rate. The crossbreds from Jersey sired progenies matured earlier in Age to First Service (AFS) and Calving (AFC) than the Jersey Horro sire. At Bako agricultural research center, the F_1 Holstein Frisian X Horro dam and Jersey X Horro sire outperformed the other crosses and local Horro in non-return rates at 90 days. As a result, the research center should concentrate on the sire and dam's breeding performance in order to improve the breed's reproduction performance.

ACKNOWLEDGMENTS

Special thanks to the Bako agricultural research center for providing us with the resources we needed from the start to the end of this research manuscript. The study was coordinated and facilitated by Assosa University and Jimma University.

COMPETING INTERESTS

There are no relevant financial or nonfinancial interests to disclose to the authors.

AUTHORS CONTRIBUTIONS

The study's conception and design were contributed to by all authors. Beshatu Jalata, Tesfaye Mediksa, and Dereje Bekele prepared the materials, collected data, and analyzed the results. Beshatu Jalata wrote the first draft of the manuscript, and all authors provided feedback on previous drafts. Habtamu Abera edited the data, edited the manuscript, designed, supervised, reviewed the literature, and wrote the final manuscript. Mohammed Aliye was in charge of supervision. The final manuscript was read and approved by all authors.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest

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