

## Reproductive Performance of Holstein Friesian Dairy Cows in a Tropical Highland Environment

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### Abstract

Any genetic improvement in dairy cattle requires information on reproductive performance in the given population. This study was carried out to evaluate the effect of non-genetic factors on reproductive performance traits of Holstein Friesian dairy cattle maintained under tropical highland environment. The data used in this study included records of cows that calved between 1979 and 2013. The overall least squares mean of Age at First Calving (AFC), Calving Interval (CI), Days Open (DO) and Number of Service Preconception (NSC) were  $39.42 \pm 0.41$ ,  $469.19 \pm 7.88$ ,  $179.89 \pm 6.82$  and  $1.9 \pm 0.05$ , respectively. All sources of variation parity sire origin and period have significant effect on most reproductive traits considered. In general, in this study the reproductive performance of Holstein Friesian cows under tropical management condition were poor. This calls a planned technical and institutional intervention to improve the efficiency of reproductive performances through accurate heat detection, timely insemination, adequate feeding for growing heifers, and proper management of postpartum reproductive problems are assumed the best intervention of choice to enhance the replacement rate of the herd and enable possible selection among the existing small herd supporting local AI bull provision of crossbreeding program.

**Keywords:** Holstein Friesian; Origin of sire; Ethiopia; Non genetic factors; Tropics

### Introduction

The overall productivity and adaptive efficiency of cattle depends largely on their reproductive performance in a given environment. Reproduction is an indicator of reproductive efficiency and the rate of genetic progress in both selection and crossbreeding programs particularly in dairy and beef production systems [1]. Some of the important parameters that determine cattle reproductive efficiency are age at first calving, number of services per conception, day's open and calving interval [2]. In the past decades however, more attention has been placed on milk production in selection programs worldwide, which resulted in a decline in health and fertility traits due to the antagonistic genetic association between milk production and functional traits [3,4]. These poor reproductive performances had resulted in a substantial economic loss because of prolonged calving intervals, increased insemination and veterinary costs, higher culling rates and excessively late age at first calving which can result in reduced lifetime milk yield and increased replacement costs [5,6].

Most cow operations would benefit economically by reducing the number of open days, decreasing culling rates due to non-pregnant females, and shortening their calving interval through better reproductive management practice [7]. In order to achieve this goal, a clear understanding of the reproductive process and factors that affect reproductive ability is useful [8]. Thus, understanding the important parameters affecting reproductive performance of dairy breeds particularly in the tropical highland is essential. This information could serve as the basis for the exploitation of genetic potential to

further dairy industry development in the region and also be used by policy makers in the process of planning and making accurate decisions pertaining to dairy development. The purpose of this study was to determine the level of reproductive performance and to evaluate non genetic factors affecting reproductive traits of Holstein Friesian dairy cows reared under tropical highland dairy production systems.

### Materials and Methods

#### Data source and management

The data for this study was from cows reared in the central highlands of Ethiopia. It includes performance records on reproduction traits of Holsteins Friesian cows that calved between 1979 and 2013. Three sea-seasons were classified based on weather and climatic conditions of the study area; June to September as long rain season, March to May as short rainy season and October to February as dry season. Due to relatively small number of observation in each year of calving or birth, calving year or birth was categorized in to five periods of 6 years interval. Lactations from first to three were considered. All parities above 3 were pooled together into parity three due to very few observations in later lactations as well as due to very high correlation among three and later lactations. Animals that have abnormal calving, i.e., abortion and stillbirths, were not included in the analysis. The data was edited in such a way that all animals with AFC between 18 to 60 months were considered as normal expected age range and those animals with records greater than 60 months age for AFC were considered in the terminal category, similarly calving interval between 300 and 900 days and days open between 21 and 500 days were included in the final analysis [9]. Sires used in the farm were

assigned into eight groups based on their source or country of origin. I.e. those imported from Cuba, Finland, Kenya, Israel, Italy, United States of America, and the remaining recruited in Holetta and unknown group from Ethiopia. Finally, a total of 1,125, 2,764, 2,773 and 3881 AFC, CI, DO and NSC, respectively were used in the final analysis to evaluate the non-genetic factors of reproductive traits (Table 1).

### Data analysis

The data were analysed using general linear model (GLM) procedures using SAS [10]. The model applied included fixed effects of period, sire origin, season and parity. Different statistical models were used for the analysis of the data. The models used for the analysis of age at first calving was referred to as model 1 whilst those used for the analysis of calving interval and days open were referred to model 2 and for number of service per conceptions model 3 was used, the details of the analytical models are as follows:

$$Y_{ijkl} = \mu + S_i + Pr_j + B_k + e_{ijkl} \quad (1)$$

Where,  $Y_{ijkl}$  = AFC of  $l$ th cow in  $K$ th sire origin,  $j$ th period of birth years,  $i$ th season of birth;  $\mu$  is overall mean;  $S_i$  is the effect of  $i$ th season of birth;  $Pr_j$  is the effect of  $j$ th period of birth years;  $B_k$  is the effect of  $k$ th sire origin and  $e_{ijkl}$  is random residual error term

Calving interval (CI), days open (DO) and number of service preconception (NSC) were analyzed with the following model.

$$Y_{ijklm} = \mu + S_i + Pr_j + P_k + Bl + e_{ijklm} \quad (2)$$

Where;  $Y_{ijklm}$  is observation on CI, DO and NSC;  $\mu$  is overall mean;  $S_i$  is the effect of  $i$ th season of calving;  $Pr_j$  is the effect of  $j$ th period of calving;  $P_k$  is the effect of  $k$ th parity;  $Bl$  is the effect of  $l$ th sire origin and  $e_{ijklm}$  is random residual error term

$$Y_{ijklm} = \mu + S_i + Pr_j + P_k + Bl + e_{ijklm} \quad (3)$$

Where;  $Y_{ijklm}$  is NSC of  $l$ th cow;  $\mu$  is overall mean;  $S_i$  is the effect of  $i$ th season of insemination,  $Pr_j$  is the effect of  $j$ th period of insemination;  $P_k$  is the effect of  $k$ th parity;  $Bl$  is the effect of  $l$ th sire origin and  $e_{ijklm}$  is random residual error term.

Variables	N	Mean	SD	Minimum	Maximum
AFC	1,125	39.26	9.8	18	60
CI	2,764	473.57	124.32	301	897
DO	2,773	184.54	107.55	25	500
NSC	3881	2.04	1.41	1	7

N: number of observations; SD: standard deviation; AFC: Age at first calving; CI: calving interval; DO: days open; NSC: number of service per conception.

Table 1: Statistical description on the data set.

## Results

### Age at first calving

The result showed that the season in which the heifers were born had no significant effect on AFC ( $P > 0.05$ ) (Table 2). The origin of sire and period of birth had significant effect on the AFC of the heifers ( $p < 0.001$ ). The result also indicated that high AFC (43.3 months) was recorded for daughters of sires originating from Finland and lowest (36.33 months) for those sires from Cuba. Similarly, Heifers born in the period 1986 to 1991 had the highest mean AFC ( $47.6 \pm 0.9$  months) while heifers born from 2005 to 2013 had the lowest mean AFC ( $28.4 \pm 0.8$  months).

Factor	N	LSM ± SE
Overall	1130	39.4 ± 0.4
CV (%)		17.5
Birth season		NS
Short rainy	257	39.7 ± 0.6a
Long rainy	514	38.8 ± 0.5a
Dry	359	39.7 ± 0.5a
Sire Origin		***
Cuba	280	36.3 ± 0.8c

Finland	88	43.3 ± 1.2a
Holetta	94	38.1 ± 0.9bc
Israel	302	39.4 ± 0.8bac
Italy	39	39.7 ± 1.5bac
Kenya	96	41.7 ± 1.15ba
Unknown	197	38.2 ± 0.7bc
USA	34	38.7 ± 1.7bac
Period of birth		***
1979-85	215	44.4 ± 1.0b
1986-91	213	47.6 ± 0.9a
1992-97	213	41.7 ± 0.8b
1998-2004	294	34.9 ± 0.8c
2005-2013	195	28.4 ± 0.8d

\*\*\* $P < 0.001$ ; \* $P < 0.05$ ; NS=Not Significant

Table 2: Least squares means and standard error (LSM ± SE) of AFC.

### Calving interval and days open

For calving interval and days open the results showed that the mean CI and DO were  $469.2 \pm 7.9$  days and  $179.9 \pm 6.8$  days, respectively (Table 3). The season of calving had no significant ( $p > 0.05$ ) effect on CI and DO; however, parity and origin of sire were a significant ( $p < 0.05$ ) sources of variation for CI and DO. The longest CI and DO was

recorded at the first parity and the shortest was during third parity. In general the result shows a declining trend in the number of days wasted from first to third parity. Moreover, on an average, daughters of those sires originated from Italy and Kenya tended to have longer CI and DO while daughters of sires that were from the USA had shorter CI and DO.

Traits		CI		DO
Factor	N	LSM $\pm$ SE	N	LSM $\pm$ SE
Overall	1250	$469.2 \pm 7.9$	1265	$179.9 \pm 6.8$
CV (%)		25		55
Season calving		NS		NS
Short rainy	828	$466.2 \pm 8.9a$	648	$179.8 \pm 7.7a$
Long rainy	1239	$470.4 \pm 8.6a$	839	$179.8 \pm 7.4a$
Dry	682	$470.9 \pm 8.2a$	1235	$180.0 \pm 7.5a$
Parity		***		***
1	845	$492.9 \pm 8.3a$	839	$206.1 \pm 7.1a$
2	654	$471.2 \pm 8.9b$	654	$178.1 \pm 7.7b$
3	1250	$443.4 \pm 8.7c$	1265	$155.5 \pm 7.5c$
Sire origin		*		*
Cuba	880	$476.4 \pm 5.2b$	866	$187.4 \pm 4.5a$
Finland	94	$453.9 \pm 14.6e$	100	$158.0 \pm 12.3d$
Holetta	224	$466.7 \pm 8.5d$	223	$173.3 \pm 7.3c$
Israel	528	$477.0 \pm 6.9c$	549	$189.4 \pm 5.91b$
Italy	57	$490.1 \pm 2.3a$	56	$197.8 \pm 14.2a$
Kenya	331	$490.3 \pm 7.5a$	331	$202.3 \pm 6.5a$
Unknown	610	$464.9 \pm 5.5c$	608	$179.1 \pm 4.7b$
USA	25	$434.2 \pm 5.7f$	25	$151.7 \pm 47.2e$
Period of calving		***		***
1981- 87	257	$450.41 \pm 12.0b$	253	$158.9 \pm 10.4b$
1988-93	560	$500.9 \pm 10.4a$	549	$202.6 \pm 9.1a$
1994-99	766	$486.3 \pm 9.2a$	757	$193.2 \pm 7.9a$
2000-2005	762	$449.0 \pm 8.9b$	776	$166.8 \pm 7.7b$
2006-2013	404	$459.2 \pm 9.2ba$	423	$177.9 \pm 7.9ba$

\*\*\* $P < 0.001$ ; NS= Not Significant

**Table 3:** Least squares means and standard error (LSM  $\pm$  SE) of CI and DO.

### Number of service

Least square means for NSC are presented in Table 4. Cows inseminated for the first time during the long rainy season had higher NSC than those cows that were inseminated for the first time during the other seasons. Origin of sire had a significant ( $p < 0.01$ ) influence on

the NSC. Similarly, a highly significant ( $p < 0.001$ ) variability was observed in the NSC for cows bred during different parties and years.

Factor	N	LSM $\pm$ SE
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<b>Overall</b>	3881	1.9 ± 0.05
<b>CV (%)</b>		67.4
<b>Season insemination</b>		**
<b>Short rainy</b>	965	1.8 ± 0.1b
<b>Long rainy</b>	1195	1.9 ± 0.1b
<b>Dry</b>	1721	2.01 ± 0.01a
<b>Parity</b>		***
<b>1</b>	1087	1.6 ± 0.1b
<b>2</b>	876	2.1 ± 0.1a
<b>3</b>	1918	2.1 ± 0.1a
<b>Sire origin</b>		**
<b>Cuba</b>	1158	2.0 ± 0.1ba
<b>Finland</b>	184	1.7 ± 0.1b
<b>Holetta</b>	318	2.0 ± 0.1ba
<b>Israel</b>	866	1.9 ± 0.1ba
<b>Italy</b>	93	1.9 ± 0.2ba
<b>Kenya</b>	421	1.9 ± 0.1ba
<b>Unknown</b>	802	2.1 ± 0.1a
<b>USA</b>	39	1.7 ± 0.2b
<b>Period of insemination</b>		***
<b>1981- 87</b>	282	1.7 ± 0.1b
<b>1988-93</b>	751	1.8 ± 0.1b
<b>1994-99</b>	947	2.0 ± 0.1ba
<b>2000-2005</b>	1070	2.0 ± 0.1a
<b>2006-2013</b>	831	2.0 ± 0.1ba
***P<0.001; *P<0.05; NS= Not Significant		

**Table 4:** Least squares means and standard error (LSM ± SE) of NSC.

## Discussion

Accurate evaluation of the reproductive performance of dairy cattle is necessary for improving husbandry practice and profitability of dairy farms. AFC has a great economic importance in the efficiency of dairy cattle production as it affects productive life of the cow and its lifetime milk production. The results of this study showed that the mean age at first calving is in agreement that reported for the same breed in central highlands of Ethiopia [11]. On the other hand, our estimate is higher than the reported values of 29.8 ± 0.4 months [12], 30.7 ± 2.1 months [13] and 29.8 ± 0.4 months [14] in other tropical countries for Friesian heifers. The slightly longer AFC of Holstein Friesian heifers in the present study could be attributed to management and other environmental factors, especially the plane of nutrition which could determine pre-pubertal growth rates, reproductive organ development, and onset of puberty and subsequent

fertility [15]. Additionally, poor management practices including problems associated with estrus manifestation and detection in tropical environments. The season in which the heifers were born had no significant ( $p>0.05$ ) effect on AFC (Table 1). This might be due to large gap in time between birth date and AFC is long enough to mask the effect of season of birth on AFC of heifers [11-16]. However, significant effects of season of birth on AFC were reported for cross breed heifers in Ethiopia and Tanzania, respectively [17,18].

In many tropical environments dairy sires are imported from different countries. The result from this study showed that origin of sire and period of birth had a significant effect on AFC. The significant effect of sire origin on the AFC was consistent with previous reports [19-21]. The effect of origin of sire might be due to the difference in adaptation attributed to origin of the animals, nutritional and reproductive management of heifers and the difference in breeding objectives of home and exporting countries population. Similarly, other researchers suggested that genotype environment interaction greatly affect AFC in different production environment [19,20]. Additionally, the wide variations in AFC over the study periods and the overall improving trend after period two (1986-91) could be due to special man-agement that was given to improve the growth rate of replacement heifers to enable them reach puberty and start production life earlier. This indicated to change in breeding objective, adaptation of Holstein Friesian breed to the existing environment, establishment of new feed processing plant and government emphasis to recruit replacement young bull for cross breeding.

The overall mean of CI reported in this study was comparable with an earlier study reported on Friesian cows in Ethiopia [11,22,23]. On the contrary, a slightly shorter CI of 396 ± 6 days [24], 403.1 ± 1.9 days [13] and 408.1 ± 2.1 days [14] have been reported for the same breed in other tropical countries. Likewise, the mean days open from this study was 179.9 ± 6.8 days (Table 3). This estimate was comparable with, 174 [23] and 177 ± 5.4 days for the same breed in the central highlands of Ethiopia [25,26]. This is, however, slightly higher than the estimates reported by Hammoud et al. [13] and Million et al. (2010) being 150 days, 130.7 ± 1.9 days and 148 ± 1.7 day for the same breed in Turkey, Egypt and Ethiopia, respectively. On the other hand, Asseged and Birhanu [27] and Asimwe and Kifaro [18] reported higher estimates being 187 days and 205 ± 2.6 days for the Holstein Friesian in Ethiopia and Tanzania, respectively. In general, both CI and DO are longer than the ideal value of 365 and 90 days, respectively. This is undesirable particularly in a production system in which there is a high demand for replacement young bulls and heifers to bring genetic improvement. The main reasons for longer CI and DO could be due to poor oestrous detection, silent heats, poor feed quality and health care and poor management.

With regard to the factors affecting CI and DO, our results indicate that except season of calving, parity, calving year and origin of sire had a significant difference on CI and DO. The non-significant effect of season on the CI was consistent with previous reports for Holstein Friesian and their cross with Zebu cows [2,17,26]. However, a significant effect of season of calving on calving interval was reported for the same breed in Egypt [13] and Ethiopian herds [11].

With an increase in lactation number a relatively shorter CI and DO was observed (Table 3). These re-sults are consistent with the results reported by Negussie et al. [2] and Gebeyehu et al. [26]. The reason for longer CI and DO in younger cows might be due to the need for high nutrient requirement for growth, milk production and maintenance at an earlier age. Thus, negative energy balance during early lactation in

high producing cows could also affect the onset of estrus and hence result in longer days open and calving interval. Likewise, origin of sire had significant ( $p < 0.05$ ) effect on both CI and DO and it is in line with Ojango and Pollott [19]. The effect of origin of sire on CI might be due to differences in management and breeding objectives of the origin and the production environment, although non-significant effect has been reported for Friesian cows in Iran [28].

NSC is one of parameters for measuring cow reproductive efficiency which basically depends on the breeding system followed and it is higher under uncontrolled natural mating and is lower where hand mating or artificial insemination is used [16]. Our results showed that the overall mean of NSC was found to be  $1.98 \pm 0.05$ . This result is comparable with the reported values of  $2.0 \pm 0.1$  [23] and 1.8 for Holstein Friesian cows in Ethiopia [11]. Nevertheless, this estimate is slightly higher than the reported values of  $1.5 \pm 0.6$  in Malawi [29] and  $1.7 \pm 0.1$  in Ethiopia [26]. Variations in the management, environment, improper heat detection and fertility status of the breeding cow leads to differences in number of services per conception [14,16]. Similarly, cows with reproductive disorders required more services per conception and had longer intervals from calving to first service and to conception [30]. In dairy herds, proper and accurate heat detection is a key to efficient reproduction. Therefore adopting four to five checks each day to determine the onset of true standing heat would give a better idea about the accurate time of insemination in many herds [26].

Several environmental factors affect NSC in dairy cows. The significant effect of the season of insemination from this study is in agreement with results of El-keraby and Aboul E [31] and Asimwe, Kifaro (2007). Similar to our finding, fewer NSC were required for heifers that conceived in the main rainy sea-season than those conceived during the other season [32]. However, non-significant effect of season of calving on NSC was reported for Holstein Friesian cows in Ethiopia [11,26,27].

Lactation number is one of the main factors affecting NSC in dairy cows. The result from this study is in agreement with reports in various production systems [11] [29,33]. The number of service per conception was lower in first parity cows compared to cows in the second parity and third parity. The possible cause of the high NSC for older cows may be related to possible effects of higher milk production on involution of the cervix and uterus infection in addition to delayed first postpartum ovulation [34]. The origin of sire had a significant ( $p < 0.01$ ) effect on NSC and our result indicated that semen from Cuba, Holetta and unknown group resulted higher number of service per conception than the other groups. This is in line with Mukasa-Mugerwa who reported the NSC greater than 2.0 expected as poor for cross breed cow in Ethiopia. Higher NSC in dairy cows may be due to variations in fertility status of the breeding bull, semen handling and its viability resulting in differences in number of services required per conception. The semen produced from locally recruited bulls form different farms (unknown group) and Holetta farm might not properly handled and coded; therefore, utilization of this semen may have reduced the fertility level of the herd due to inbreeding and viability.

Period of insemination had significant ( $p < 0.001$ ) effect on NSC and this was in agreement with reports of Chagunda et al. [29] and Hammoud et al. [13]. However, Million et al. [11] reported non-significant effect of year of calving on NSC. Our result in general showed that cows inseminated in 1988 had lower NSC ( $1.6 \pm 0.2$ ) and higher NSC ( $2.5 \pm 0.1$ ) was recorded in 1999. After 1999, the herd showed consistent deterioration in NSC (Table 4) which might be due

to poor reproductive management in the herd including poor heat detection and timely insemination.

## Conclusion

Reproductive performance of Holstein Friesian herd in the tropical highland of Ethiopia had been mainly affected by period of calving/birth, parity and origin of sire. However, merely NSC was affected by sea-season of calving among the studied traits. The overall performance of all reproductive traits under this study indicated poor performance of the herd comparative to its counterpart herd in the same altitude range of the tropics and ideal ranges for dairy cows. This wastage of months to reach first age of calving and cyclical nature of the cows can be corrected by better feeding management and proper heat detection. Therefore, special emphasis has to be given on these factors as key entry point for increasing reproductive efficiency to enhance the replacement rate of the herd for crossbreeding program in tropics.

## Availability of Data and Materials

The datasets used during the current study are available from the corresponding author.

## Authors' Contributions

WA, MA and EN designed the research, analyzed the data, interpret the results, drafted the manuscript and write up the manuscript. At last the authors revised the manuscript, read and approved the final version.

## Competing Interests

The authors declare that they have no conflict of interest.

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