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**COLLEGE OF VETERINARY MEDICINE AND AGRICULTURE**

**DEPARTMENT OF ANIMAL PRODUCTION STUDIES**

**ON FARM AND ON STATION FERTILITY STATUS OF DAIRY HERDS IN WEST**

**SHOA, ETHIOPIA**

**BY**

**GEMEDA TUNTUNA WAKE**

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**BISHOFTU, ETHIOPIA**



**ON FARM AND ON STATION FERTILITY STATUS DAIRY HERDS IN WEST SHOA,  
EHTIOPIA**

**By**

**Gemeda Tuntuna Wake**

**A Thesis Submitted to the College of Veterinary Medicine and Agriculture of Addis Ababa  
University in Partial Fulfillment of the Requirements for the Degree of Masters in Animal  
Production**

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**Department of Animal Production Studies**

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On Farm and On Station Fertility Status of Dairy Herds in West Shoa Zone, Ethiopia.

Submitted by: Gemeda Tuntuna                      \_\_\_\_\_                      \_\_\_\_\_  
Name of Student                                      Signature                                      Date

Approved for submittal to a thesis assessment committee

1. Professor. Gebeyehu Goshu                      \_\_\_\_\_                      \_\_\_\_\_  
Major Advisor                                      Signature                                      Date
2. Ulfina Galmessa (Ph.D.)                      \_\_\_\_\_                      \_\_\_\_\_  
Co-Advisor                                      Signature                                      Date
3. Gebreyohannes Berhane (Ph.D.)                      \_\_\_\_\_                      \_\_\_\_\_  
Department Head                                      Signature                                      Date

**Approval Sheet**  
**Addis Ababa University**  
**College of Veterinary Medicine and Agriculture**  
**Department of Animal Production Studies**

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As members of the Examining Board of the Final MSc open defense, we certify that we have read and evaluated the thesis prepared by: **Gemeda Tuntuna Wake**. Entitled: “**On Farm and on Station Fertility Status of Dairy Herds in West Shoa Zone, Ethiopia**” and recommend that it be accepted as fulfilling the thesis requirement for the degree of Master of Science in Animal Production.

Professor. Getachew Terefe

Chairperson

Signature

Date

Gebreyohannes Berhane (PhD).

Internal Examiner

Signature

Date

Tamirat Degefa (PhD).

External Examiner

Signature

Date

Professor. Gebeyehu Goshu

Major Advisor

Signature

Date

Ulfina Galmessa (PhD)

Co- Advisor

Signature

Date

Gebreyohannes Berhane (PhD)

Department Head

Signature

Date

## **DEDICATION**

This thesis paper is dedicated to all my family members for their unwavering support, unreserved prayers, encouragement and intellectual guidance to achievement throughout my life.

## **STATEMENT OF THE AUTHOR**

First and foremost, I declare and affirm that this thesis is my own original work. I followed all ethical and technical principles of scholarship and any scholarly material used in the thesis has been acknowledged with a citation. This thesis submitted in partial fulfillment of the requirements for degree of Master Science in Animal Production at Addis Ababa University, College of Veterinary Medicine and Agriculture, Bishoftu Campus.

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Name:                               Gemedat Tuntuna  
Signature                           \_\_\_\_\_

Place:                               Addis Ababa University

Date of submission:       06/11/2013 EC

## **BIOGRAPHICAL SKETCH**

The author was born on September 20, 1990 G.C in Arsi Zone, Ziway-Dugda woreda, Ogolcho town. He attended his elementary education at Herara Mandoyyu and Batu number one primary school from 1998 to 2006 G.C. He continued his secondary education in Batu high school and preparatory school from 2007 to 2010 G.C. After completion of his preparatory school education in Batu, he joined Ambo University in 2012 G.C and graduated with a BSc in Animal Science in July, 2014 G.C. After graduation, he employed in Lume woreda agricultural offices as livestock expert in March, 2015. After serviced nearly a year in the office, the author joined Ethiopian Institute of Agricultural Research, Debre Zeit Agricultural Research Center and has worked as an assistant researcher until he joined the postgraduate program of Addis Ababa University, College of Veterinary Medicine and Agriculture in October, 2019 to pursue his MSc study in Animal Production.

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## LIST OF ABBREVIATIONS

|                |   |
|----------------|---|
| AFC            | Age at First Calving  |
| AI             | Artificial Insemination   |
| A.M            | Ante Meridiem   |
| AFS            | Age at first Service  |
| ALPPIS         | Addis Livestock Production and Productivity Improvement Service |
| ARTP           | Agricultural Research and Transformation project                |
| ATVET          | Agricultural Technical and Vocational Education Training        |
| BCS            | Body condition score  |
| CI             | Calving Intervals   |
| CCI            | Conception to Calving Intervals                                 |
| CSA            | Central Statistical Agency                                      |
| CV             | Coefficient of Variation  |
| DF             | Degree Freedom  |
| DMY            | Daily Milk Yield  |
| DO             | Days Open   |
| F <sub>1</sub> | First filial generation   |
| F <sub>2</sub> | Second filial generation  |
| F <sub>3</sub> | Third filial generation   |
| G.C            | Gregorian Calendar  |
| GLM            | General Linear Model  |
| HARC           | Holeta Agricultural Research Center                             |
| HF             | Holstein Friesian   |
| HH             | Household   |
| ILRI           | International Livestock Research Institute                      |
| m.a.s.l.       | the meter above sea level                                       |
| MYL            | Milk Yield per Lactation  |
| NAIC           | National Artificial Insemination Center                         |
| NEB            | Negative Energy Balance   |

### **LIST OF ABBREVIATIONS (Continued)**

|        |   |
|--------|---|
| LL     | Lactation Length  |
| LSM    | Least Square Mean   |
| PARI   | Program of Accompanying for Agricultural Innovation       |
| P.M    | Post Meridiem   |
| RFM    | Retained Fetal Membrane                                   |
| SAS    | Statistical Analysis System                               |
| SD     | Standard Deviation  |
| SE     | Standard Error  |
| SPC    | Number of Service Per Conception                          |
| SPSS   | Statistical Packages for Social Sciences                  |
| WDLDFO | Walmera District Livestock Development and Fishery Office |
| VWP    | Voluntary Waiting Period                                  |
| WWS    | Worldwide Sire  |

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## ABSTRACT

*The on-station part of the current study was conducted at Holeta research center dairy farm to determine fertility and productive traits of dairy cattle. The dataset between 1976 and 2019 on fertility and productive traits (n=30975) were investigated and analyzed using the GLM analysis procedure of SAS 2008 software to determine the fixed effects of genetic group, year, season and parity. The fixed effect genetic group and year cause significant ( $P<0.0001$ ) difference in all fertility and lactation performance. Similarly, the parity of cows had a highly ( $p<0.0001$ ) influence on fertility and productive traits except NSC. The productive traits like daily milk yield, lactation length and lactation milk yield were sensitive to seasonal variation. The overall least squares mean for age at first service, age at first calving, calving interval, days open, number of services per conception were  $29.98 \pm 10.23$  months,  $39.16 \pm 8.58$  months,  $496.24 \pm 42.19$  days,  $216.81 \pm 41.72$  days,  $1.85 \pm 1.37$  and daily milk yield, lactation length and lactation milk yield  $4.86 \pm 1.63$  liters,  $287.77 \pm 92.81$  days and  $1488.23 \pm 70.14$  liters.*

*The on-farm part of this study was conducted in three districts of West Shoa Zone of Oromia regional state initiated to assess fertility status of dairy herds and possible cause of infertility in dairy cattle. Data were collected using semi structured questionnaire survey. A total of 180 dairy producers (60 household from each) were randomly selected for individual interviews using a semi-structured questionnaire. The data were analyzed using Statistical Packages for the Social Sciences software version 26. The survey results showed that higher education was the highest educational level from Ambo woreda, and the age group of the respondents ranged from 20 to 79 years. The primary feeding system practiced was combination feeding with 53.3%, 56.7% and 45%, respectively, in Walmera, Adea Berga and Ambo. The main breeding system dairy producers utilized was both Artificial insemination and natural mating (70%, 60% and 46.7%), respectively, in Walmera, Adea Berga and Ambo. The mean shortest age at first service and age at first calving for local and crossbred, respectively, were  $47.9 \pm 9.8$  and  $19.9 \pm 5.8$  months and  $56.9 \pm 9.8$  and  $28.9 \pm 5.8$  months from Adea Berga and Ambo. The number of services per conception was 2.5 for local cows and 1.8 for crossbred cows. The higher mean ( $\pm$ SD) of daily milk yields were  $2.2 \pm 1.3$  and  $11.2 \pm 4.5$  liters, respectively, in Adea Berga for Local and crossbred cows. The mean ( $\pm$ SD) shortest calving intervals was  $20.3 \pm 7.0$  and  $13.1 \pm 1.9$  for local and crossbred cows.*

Key words: Breed, Dairy, Fertility status, On farm, On station.

## 1. INTRODUCTION

In Ethiopia, total cattle population is expected to be around 70.29 million with total milk production around 4.69 billion liters. Local breeds accounted for about 97.4% of the entire cattle population in the country, and they are in the hands of smallholder subsistence farmers, which accounted for 85% of the human population. The remaining are hybrid and exotic breeds, respectively, that accounted for about 2.3% and 0.31% (CSA, 2020/21). The per capita milk consumption was only about 19 kg/year, which is much lower than per capita averages of African and World, respectively, 40 kg/year and 105 kg/year (BrasESCO *et al.* 2019).

Historically, the use of conventional animal breeding techniques for the genetic enhancement of dairy cattle to increase the productivity of local breeds exceeds six decades (Leakey, 2009). Genetic upgrading programs have been launched to improve dairy cattle to increase the milk production of local breeds by importing pure temperate breed of cows to combine gene or blood level of the two genotypes. However, due to both technical and non-technical limitations, these attempts were met with little success (Lobago *et al.*, 2007 cited by Kumar *et al.*, 2014).

The term fertility is applied to the cow denotes the desire and ability to mate, the capacity to conceive and to nourish the embryo and finally the power to expel a normal calf and fetal membrane. Thus, fertility trait of the breeding female is probably the single most important factor that is a prerequisite for a sustainable dairy production system and influencing productivity. The most common indices of fertility traits are age at first service, age at first calving, calving interval, number of services per conception, and days open. Poor fertility due either to late first service anestrus, or repeat breeding continues to be a major problem in dairy herds. The mean ( $\pm$ SE) AFC obtained for highland zebu was estimated at  $53 \pm 0.42$  months (Lemma *et al.*, 2010). Long calving intervals would demonstrate the prevalence of fertility disorders or poor herd management. Mean ( $\pm$ SE) Calving interval for indigenous breeds vary from  $11.8 \pm 1.26$  to  $15.6 \pm 0.86$  months (Lemma *et al.*, 2010; Haile *et al.*, 2008). Haile *et al.* (2008) reported that values of the NSC greater than 2 should be regarded as poor. Previous report showed that the number of services per conception for indigenous breeds (Boran, Begait, Arsi and Fogera) ranged from 1.6 to 2.6, i.e. (2.17, 1.6, 2.6 and 2.24), respectively, (Gebeyehu *et al.*, 2005; Dessalegn *et al.*, 2016).

Most forms of functional infertility led to anestrus that means a failure of cows to show estrus (Abraham, 2017). Infertility in lactating dairy cows is also predisposed to disturbed or aberrant immune function that leads to reduced immune competency and is consequently more susceptible to disease, particularly invasive pathogens that cause mastitis (Fair, 2015). During early pregnancy, the conceptus and other endocrine mediators, including progesterone, actively shape the maternal immune response (Ott *et al.*, 2014). Fetal cells can regulate not only by the secretion of specific factors interferon-tau but also by regulating their protein expression to avoid excessive maternal recognition by the local immune system (Oliveira *et al.*, 2012).

Holeta Agricultural Research Center (HARC) is one of the main centers that has been playing a great role in the improvement of dairy cattle since 1966. Borena from indigenous cattle has mainly been crossed with Holstein-Friesian and Jersey to combine productivity and adaptability in the crossbreds. Several studies have been done on dairy herd performance at HARC that assessed genetic and cross-breeding effects on productive and fertility traits. Since fertility traits have not a biological constant due to environmental variability, ongoing selection and use of different sires on the performance of crossbred could not reflect the current performance of the herd on the farm. West Shoa zone is also one that has enough intensive dairy management system in Ethiopia. Although little information is available about the effect on fertility status and lactation performance of dairy cattle at research and ranch condition, still it needs attention. Sufficient studies have not been conducted on the fertility status of dairy herds. Therefore, the objectives of this study were to estimate the status of the fertility and lactation performance of dairy herds in the West Shoa Zone, Oromia region, Ethiopia.

## 2. LITERATURE REVIEW

### 2.1. Reproductive Performance of Dairy Herds in Ethiopia

Reproductive performance is a measure of the speed at which cows get pregnant after the voluntary waiting period. It is one of the major factors that affect the productivity and profitability of a dairy herd. The production of milk and reproductive stock is not possible unless the cow reproduces. Reproductive performance is calculated as the number of cows that got pregnant divided by the number of cows that were eligible to get pregnant. The fertility of dairy cows affects the genetic improvement and financial sustainability of dairy herds. Fertility is an economically important trait in dairy production.

The dairy industry's ultimate goal is to run a cost-effective operation, which is determined by the cows' reproductive efficiency. In many animal production systems, reproductive performance is biologically critical and essential for profitability. The reproductive efficiency of a herd is an important factor in the global productivity of dairy cattle. The cost of a longer calving interval, higher insemination costs, lower returns from calves born, and forced replacements in the event of culling can all be due to poor fertility. Dairy cattle breed productivity is primarily determined by their reproductive success and service per conception production. The AFS, AFC, NSC, DO, and CI are important fertility traits that are crucial to evaluating the feasibility of dairy production (Hammoud *et al.*, 2010, Tadele and Nibret, 2014).

Genetic improvement of all economically important traits is closely related to the rate of reproduction (Gizaw *et al.*, 2011). Poor fertility is caused by pregnancy failure of the cow, primarily due to anestrus, failure of the cow to maintain pregnancy and loss of the calf (Belay *et al.*, 2012). This causes a delay in age at first calving and long calving intervals. Research has been undertaken to determine and improve fertility traits of local and crossbred cows under relatively controlled conditions at research centers, government-owned farms and in some urban and peri-urban dairy areas in the central highlands of Ethiopia (Million and Tadelle, 2003; Million *et al.*, 2004). In many cases, fertility status of cattle was measured mainly by considering parameters such as age at first service and calving, days open, calving interval, and the number of services per conception (Shiferaw *et al.*, 2003).

### 2.1.1. Age at first service (AFS)

AFS is the age at which heifers attain body condition and sexual maturity for accepting service for the first time. It includes the period from the birth of heifer to the first insemination. The time between the birth of a heifer and the first service at the age when the animal has reached breeding maturity and is capable of normal gravidity is known as the age at first effective service. Age at first effective service is one of the most essential fertility properties in dairy cattle. Age at first effective service is determined within defined time limits. Bottom limit is date of birth, and top limit date of conception (Novakovic *et al.*, 2017). AFS signals for the beginning of heifer's performance influences both the productivity and reproductive life of the female and then influences her lifetime calf crop.

Age at first service of heifers could be attributed to factor such as breeds or level exotic blood which have influence oestrus cycle and the time of mating the heifers. *Bos taurus* or exotic breed heifers expected to exhibit fast growth and attain higher weights at relatively younger ages whereas *Bos indicus* or indigenous heifers exhibit slow growth and not attain required weights at relatively younger ages. The average age at puberty ranges from 8 to 10 months for European-type dairy cows and 17-27 months for Zebu dairy cows (Novakovic *et al.* 2017).

The period in which heifers were born have impact on age at first service. Poor feeding and management have been the reason for longest age at first service in earlier period because a majority of farmers at that time had no experience in dairy cattle management practices and dairy technologies utilization. In the tropics, authors documented different impacts of season and year on the AFS trait. The season was not affected, but the year of calving had a considerable impact (Gebeyehu *et al.*, 2005 and Berhanu and Chakravarty, 2014). On the other hand, Mengistu *et al.* (2016) found that season has a substantial impact on AFS.

AFS also significantly influenced by the seasons in which the heifers were born. Differences in age at first service between seasons might have been attributed to seasonal fluctuations in quality and quantity of forage or pasture and other supplementary feeds availability. Calves born during the dry season tended to have highest age at first service while those born during the long rain season had the lowest age at first service. Inappropriate feed supply and differences in management systems may bring variations in age at first service in different areas (Gebeyehu *et al.*, 2005).

### 2.1.2. Age at first calving (AFC)

Age at first calving is the age at which heifers calve for the first time. The beginning of a productive life of the heifer is called age at first calving. It is the period between birth and first calving. Age at first calving is closely related to the rearing intensity and has an impact on generation interval and response to selection in a breeding program. It influences the cow productive and reproductive life, both directly and indirectly, through its effect on her lifetime calf crop and milk production, as well as the cost of upbringing (Hammoud *et al.*, 2010; Gebrekidan *et al.*, 2012). When a heifer reaches the age of first calving, it turns from a non-producing costly item into an income-generating cow. Heifers are usually mated when they are mature enough to withstand the stress of parturition and lactation in a controlled breeding system. It is recommended that heifers calve between 23 and 25 months of age, which is considered as optimum that increase profitability of the dairy business (Hammoud *et al.*, 2010).

Age at first calving of heifers could be attributed to factors such as breeds which have influence oestrus cycle and the time of mating the heifers. The prolonged age at first calving of *Bos indicus* heifers could be attributed to factors such as poor nutrition and management practices including poor heat detection at the time of mating the heifers. With good nutrition it is expected that *Bos indicus* heifers would exhibit fast growth and attain higher weights at relatively younger ages.

The period in which heifers were born have a significant on age at first calving. Poor feeding and management have been the reason for highest age at first calving during earlier period since a majority of farmers at that time had no experience in dairy cattle management practices and dairy technologies utilization.

AFC also significantly influenced by the seasons in which the heifers were born. Differences in age at first service between seasons might have been attributed to seasonal fluctuations in quality and quantity of forage or pasture and other supplementary feeds availability. Calves born during the dry season tended to have highest age at first service while those born during the long rain season had the lowest age at first service. The estimated mean of age at first service and age at first calving of dairy herds in Ethiopia reported by different scholars were summarized in the Table 1.

Table 1. Age at first service and age at first calving of dairy cows in Ethiopia

| <b>Breed</b>                         | <b>AFS (Months)</b> | <b>AFC (months)</b> | <b>Sources</b>                 |
|--------------------------------------|---------------------|---------------------|--------------------------------|
| Borena                               | 32 ± 1.4            | 44 ± 1.5            | Aynalem <i>et al.</i> (2011)   |
| Horro                                | 46.79 ± 1.03        | 48.3                | Sisay (2015)                   |
| Horro                                | 48.42 ± 0.05        | 58.08 ± 0.07        | Ayantuu <i>et al.</i> (2012)   |
| Fogera                               | 42.24±0.05          | 51.4 ± 0.05         | Assemu <i>et al.</i> (2016)    |
| Ogaden                               | 34.4 ±2.28          | 492.9 ± 13.23       | Getinet <i>et al.</i> (2009)   |
| HF × Arsi                            | 33.62 ± 0.71        | 42.84 ± 0.84        | Wassie <i>et al.</i> (2015)    |
| HF × Borena                          | 30.47 ± 0.85        | 39.49 ± 0.83        | Wassie <i>et al.</i> (2015)    |
| HF × Borena                          | 29.30 ± 0.21        | 37.99 ± 0.44        | Belay and Chackravarty (2014)  |
| HF × Borena                          | 26.80 ± 0.34        | 476.35 ± 3.91       | Getahun <i>et al.</i> (2019)   |
| HF × Borena                          | 31.33 ± 0.44        | 41.08 ± 0.44        | Mengistu <i>et al.</i> (2016)  |
| Friesian ×Horro                      | 33.44±0.7           | 43.69±0.7           | Sisay (2015)                   |
| Jersey ×Horro                        | 31.32±1.0           | 42.02±1.1           | Sisay (2015)                   |
| Friesian ×Fogera                     | 36.8 ± 0.8          | -                   | Gebeyehu <i>et al.</i> (2005)  |
| HF × Zebu (50%)                      | 27 ± 0.7            | 39 ± 0.6            | Haile <i>et al.</i> (2009b)    |
| HF × Zebu (62.5%)                    | 28 ± 1.0            | 41 ± 1.0            | Haile <i>et al.</i> (2009b)    |
| HF × Zebu (75%)                      | 28 ± 0.9            | 40 ± 0.9            | Haile <i>et al.</i> (2009b)    |
| HF × Zebu (87.5)                     | 28 ± 1.2            | 39 ± 1.3            | Haile <i>et al.</i> (2009b)    |
| F <sub>1</sub> Jersey                | -                   | 39.50 ± 8           | Kefena <i>et al.</i> (2006a)   |
| F <sub>2</sub> Jersey                | -                   | 44.07 ± 5           | Kefena <i>et al.</i> (2006a)   |
| HF × local (50% F <sub>1</sub> )     | -                   | 35.91 ± 1.3         | Million <i>et al.</i> (2006)   |
| HF × local (50% F <sub>2</sub> )     | -                   | 41.91 ± 1.8         | Million <i>et al.</i> (2006)   |
| HF × local (50% F <sub>3</sub> )     | -                   | 45.60 ± 2.6         | Million <i>et al.</i> (2006)   |
| HF × local (75% F <sub>1</sub> )     | -                   | 40.77 ± 1.2         | Million <i>et al.</i> (2006)   |
| HF × local (75% F <sub>2</sub> )     | -                   | 45.32 ± 2.7         | Million <i>et al.</i> (2006)   |
| Jersey × local (50% F <sub>1</sub> ) | -                   | 38.60 ± 2.5         | Million <i>et al.</i> (2006)   |
| Jersey × local (50% F <sub>2</sub> ) | -                   | 44.43 ± 2.3         | Million <i>et al.</i> (2006)   |
| Jersey × local (50% F <sub>3</sub> ) | -                   | 32.22 ± 3.3         | Million <i>et al.</i> (2006)   |
| Jersey × local (75% F <sub>1</sub> ) | -                   | 46.91 ± 3.8         | Million <i>et al.</i> (2006)   |
| Jersey × local (75% F <sub>2</sub> ) | -                   | 34.25 ± 4.6         | Million <i>et al.</i> (2006)   |
| HF × Borena (50% F <sub>1</sub> )    | 27.0 ± 0.45         | 37.0 ± 0.47         | Getahun <i>et al.</i> (2019)   |
| HF × Borena (50% F <sub>2</sub> )    | 34.8 ± 0.82         | 44.6 ± 0.87         | Getahun <i>et al.</i> (2019)   |
| HF × Borena (50% F <sub>3</sub> )    | 33.0 ± 1.02         | 44.5 ± 1.08         | Getahun <i>et al.</i> (2019)   |
| HF × Borena (75% F <sub>1</sub> )    | 31.3 ± 0.81         | 42.4 ± 0.85         | Getahun <i>et al.</i> (2019)   |
| HF × Borena (75% F <sub>2</sub> )    | 30.2 ± 1.58         | 39.9 ± 1.66         | Getahun <i>et al.</i> (2019)   |
| HF × Local (West Shoa)               | 26.83 ± 0.54        | 35.87 ± 0.10        | Megersa <i>et al.</i> (2016)   |
| Pure local (West Shoa)               | 43.44 ± 0.08        | 52.35 ± 0.09        | Megersa <i>et al.</i> (2016)   |
| HF 50% (Walmera)                     | 29.02±2.65          | 38.14±5.43          | Ketema <i>et al.</i> (2018)    |
| HF >50% (Walmera)                    | 22.69±3.98          | 31.75±4.08          | Ketema <i>et al.</i> (2018)    |
| Pure Local (Walmera)                 | 42.23±7.4           | 51.73 ± 6.97        | Ketema <i>et al.</i> (2018)    |
| HF × Local (West Shoa)               | 32.11±1.23          | 40.79 ± 1.23        | Bayissa <i>et al.</i> (2017)   |
| Pure Local (West Shoa)               | 45.27±0.47          | 57.08 ± 0.61        | Bayissa <i>et al.</i> (2017)   |
| HF × Local (Bishoftu)                | 18.7 ± 3.7          | 27.0 ± 3.7          | Dessalegn <i>et al.</i> (2016) |
| HF × Local (Akaki)                   | 18.7 ± 3.5          | 26.9 ± 5.4          | Dessalegn <i>et al.</i> (2016) |

### 2.1.3. Calving intervals (CI)

Calving interval is the interval between consecutive calving. The gap between two successive calving is called the calving interval (Mulugeta and Belayeneh, 2013). It is a function of days open and gestation length. Since gestation length is more or less constant for a given breed, the number of days open becomes the sole variable of calving interval. A calving interval of 12 months is considered ideal assuming an average gestation period of 280 days, nearly 85 days would remain for post-calving conception to occur. Calving interval is an important factor in measuring breeding efficiency and directly correlates with the economics of milk production. Reproduction in dairy cows with regular and shorter calving intervals (365-420 days) is a key feature for the rapid multiplication of the breeding stocks.

Breeds or level of exotic breed of dairy cows are source of variation in calving interval. *Bos indicus* dairy cows had a mean calving interval of longer compared to *Bos taurus* or exotic breed cows. High-grade dairy cows have longer calved intervals than the F<sub>1</sub> crosses. F<sub>2</sub> crosses had a longer calving interval than F<sub>1</sub> crosses (Million *et al.*, 2006). Calving interval (CI) was shorter for Jersey crosses compared to Friesian crosses (Demeke, 2004) indicating the superiority of Jersey crosses over Friesian crosses in terms of adaptation to the local condition. Such a differences could cause by failure of farmers to detect heat signs after calving thus prolonging the interval and also associated with low nutritional status of the cows, which did not allow them to recuperate fast enough after calving.

Year effect on calving intervals in the tropics has been reported to be indirect due to dynamic climatic changes which are frequently associated with forage fluctuations, disease pattern and changes in management by farmers across the years.

Parity have impact on the calving interval trait. As parities in dairy cows increases calving intervals decreases. This could be associated with improvement in reproductive management and it also indicates that physiological maturity is attained with advanced age of cows. Previous studies revealed that the predicted mean of calving intervals for dairy herds done with different genetic groups both on station and on farm in Ethiopia are presented. in Table 2.

Table 2. Calving interval for dairy cows in Ethiopia

| <b>Breed</b>                         | <b>CI (months)</b> | <b>Sources</b>                 |
|--------------------------------------|--------------------|--------------------------------|
| Borena                               | 14.63 ± 0.33       | Haile <i>et al.</i> (2009b)    |
| Horro                                | 15.5 ± 0.25        | Million <i>et al.</i> (2006)   |
| Fogera                               | 21.18 ± 0.70       | Assemu <i>et al.</i> (2016)    |
| HF × Arsi                            | 15.85 ± 0.11       | Wassie <i>et al.</i> (2015)    |
| HF × Borena                          | 15.88 ± 0.16       | Wassie <i>et al.</i> (2015)    |
| Borena × HF and Jersey               | 15.41 ± 0.29       | Kefena <i>et al.</i> (2011)    |
| Jersey × Horro                       | 12.76 ± 0.3        | Sisay (2015)                   |
| Friesian × Horro                     | 13.43 ± 0.2        | Sisay (2015)                   |
| HF × Borena                          | 13.52 ± 0.11       | Mengistu <i>et al.</i> (2016)  |
| HF × Borena (50%)                    | 14.07 ± 0.33       | Haile <i>et al.</i> (2009b)    |
| HF × Zebu (62.5%)                    | 14.87 ± 0.40       | Haile <i>et al.</i> (2009b)    |
| HF × Zebu (75%)                      | 14.77 ± 0.37       | Haile <i>et al.</i> (2009b)    |
| HF × Zebu (87.5%)                    | 14.77 ± 0.7        | Haile <i>et al.</i> (2009b)    |
| F <sub>1</sub> Jersey                | 15.3 ± 0.3         | Kefena <i>et al.</i> (2006a)   |
| F <sub>2</sub> Jersey                | 17.17 ± 0.17       | Kefena <i>et al.</i> (2006a)   |
| 75% Jersey                           | 17.60 ± 0.17       | Kefena <i>et al.</i> (2006a)   |
| HF × local (50% F <sub>1</sub> )     | 14.63 ± 0.35       | Million <i>et al.</i> (2006)   |
| HF × local (50% F <sub>2</sub> )     | 14.62 ± 0.99       | Million <i>et al.</i> (2006)   |
| HF × local (50% F <sub>3</sub> )     | 15.23 ± 0.97       | Million <i>et al.</i> (2006)   |
| HF × local (75% F <sub>1</sub> )     | 15.97 ± 0.43       | Million <i>et al.</i> (2006)   |
| HF × local (75% F <sub>2</sub> )     | 14.62 ± 0.99       | Million <i>et al.</i> (2006)   |
| Jersey × local (50% F <sub>1</sub> ) | 13.90 ± 0.54       | Million <i>et al.</i> (2006)   |
| Jersey × local (50% F <sub>2</sub> ) | 16.20 ± 0.57       | Million <i>et al.</i> (2006)   |
| Jersey × local (50% F <sub>3</sub> ) | 14.30 ± 2.02       | Million <i>et al.</i> (2006)   |
| Jersey × local (75% F <sub>1</sub> ) | 12.38 ± 1.15       | Million <i>et al.</i> (2006)   |
| Jersey × local (75% F <sub>1</sub> ) | 14.68 ± 1.71       | Million <i>et al.</i> (2006)   |
| HF × Borena (50% F <sub>1</sub> )    | 15.37 ± 0.20       | Getahun <i>et al.</i> (2019)   |
| HF × Borena (50% F <sub>2</sub> )    | 16.69 ± 0.46       | Getahun <i>et al.</i> (2019)   |
| HF × Borena (50% F <sub>3</sub> )    | 15.73 ± 0.57       | Getahun <i>et al.</i> (2019)   |
| HF × Borena (75% F <sub>1</sub> )    | 17.26 ± 0.48       | Getahun <i>et al.</i> (2019)   |
| HF × Borena (75% F <sub>2</sub> )    | 12.85 ± 1.14       | Getahun <i>et al.</i> (2019)   |
| HF × Local (West Shoa)               | 14.59 ± 0.04       | Megersa (2016)                 |
| Pure local (West Shoa)               | 24.63 ± 0.03       | Megersa (2016)                 |
| HF 50% (Walmera)                     | 14.48 ± 1.19       | Ketema <i>et al.</i> (2018)    |
| HF > 50% (Walmera)                   | 14.02 ± 1.04       | Ketema <i>et al.</i> (2018)    |
| Pure Local (Walmera)                 | 15.03 ± 1.04       | Ketema <i>et al.</i> (2018)    |
| HF × Local (West Shoa)               | 17.69 ± 0.86       | Bayissa <i>et al.</i> (2017)   |
| Pure local (West Shoa)               | 20.93 ± 0.22       | Bayissa <i>et al.</i> (2017)   |
| HF × Local (Bishoftu)                | 13.0 ± 2.1         | Dessalegn <i>et al.</i> (2016) |
| HF × Local (Akaki)                   | 13.8 ± 1.9         | Dessalegn <i>et al.</i> (2016) |

#### 2.1.4. Days open (DO)

Days open refers to the interval from calving to conception i.e., the number of days between parturition and the insemination that resulted in a pregnancy. Calving to conception interval or days open is the number of days between calving to conception and influences the profitability of the dairy industry. Days open should not exceed 80 to 85 days if a calving interval of 12 months is to be achieved. This requires the re-establishment of ovarian activity soon after calving and high conception rates.

Breeds or Level of exotic blood is source of variation for days open. The Bos indicus dairy cows had longer days open than Bos taurus or exotic breeds. The high-grade heifers had longer days open than F<sub>1</sub> crosses. This variation between breeds or level of exotic blood associated to production and productivity of animals, high producing animals have shorter time to return to their reproduction. It also influenced by the length of time for the uterus to completely involutes, resumption of the normal ovarian cycle, the occurrence of silent ovulation, the accuracy of heat detection, management, semen quality, and skill of inseminator or efficiency of bull (Melku *et al.*, 2011).

The effects of period and season of calving on days open associated with the improvement in the reproductive management by farmers and poor-quality feeds obtained during the dry periods resulted into longer days open for cows that calved during those periods because animals take a longer time to recover after calving. The long days open in the dry season and short in the rain season expected because cows/heifers that calved during the wet season received adequate feeds in terms of quality and quantity thus could recover within a short time compared to those that calved during the long dry season where there in-adequate nutrients.

Parity have impact on the days open trait. Animals that calved in parity one had the highest mean DO follow by those in second, third and etc. This could be due to physiological stress experienced by the first calvers in early lactation. High milk yields during early lactation are suspected to increase days open, perhaps due to biological antagonism between energy balance and reproductive cycling. Estimated mean of days open for dairy herds Ethiopia reported by different scholars were summarized in Table 3.

Table 3. Estimates of days open of dairy herds in Ethiopia

| <b>Breed</b>                      | <b>Days open(days)</b> | <b>Source</b>                 |
|-----------------------------------|------------------------|-------------------------------|
| Borena                            | 141 ± 7                | Aynalem <i>et al.</i> (2011)  |
| Horro                             | 88.3 ± 2.03            | Sisay (2015)                  |
| Fogera                            | 285 ± 4.3              | Menale <i>et al.</i> (2011)   |
| HF × Arsi                         | 193.77 ± 4.06          | Wassie <i>et al.</i> (2015)   |
| HF × Borena                       | 195.47 ± 4.74          | Wassie <i>et al.</i> (2015)   |
| HF × Borena                       | 134.84 ± 3.51          | Mengistu <i>et al.</i> (2016) |
| Friesian Cows                     | 177                    | Gebeyehu (2007)               |
| Friesian × Horro                  | 123                    | Gizaw <i>et al.</i> (2011)    |
| Jersey × Horro                    | 109                    | Gizaw <i>et al.</i> (2011)    |
| Holstein Friesian × Zebu          | 155                    | Belay <i>et al.</i> (2012)    |
| HF × Borena (50%)                 | 127 ± 7                | Aynalem <i>et al.</i> (2011)  |
| HF × Borena (62.5%)               | 135 ± 8                | Aynalem <i>et al.</i> (2011)  |
| HF × Borena (75%)                 | 142 ± 8                | Aynalem <i>et al.</i> (2011)  |
| HF × Borena (87.5 %)              | 134 ± 14               | Aynalem <i>et al.</i> (2011)  |
| F <sub>1</sub> Friesian           | 173.19 ± 5             | Kefena <i>et al.</i> (2006a)  |
| F <sub>2</sub> Friesian           | 173.5 ± 2              | Kefena <i>et al.</i> (2006a)  |
| F <sub>1</sub> Jersey             | 162.75 ± 4             | Kefena <i>et al.</i> (2006a)  |
| F <sub>2</sub> Jersey             | 183 ± 2                | Kefena <i>et al.</i> (2006a)  |
| 75% Friesian                      | 169.17 ± 3             | Kefena <i>et al.</i> (2006a)  |
| 75% Jersey                        | 168.55 ± 2             | Kefena <i>et al.</i> (2006a)  |
| HF × Borena (50% F <sub>1</sub> ) | 180.82 ± 6.03          | Getahun <i>et al.</i> (2019)  |
| HF × Borena (50% F <sub>2</sub> ) | 222.67 ± 13.48         | Getahun <i>et al.</i> (2019)  |
| HF × Borena (50% F <sub>3</sub> ) | 192.06 ± 17.64         | Getahun <i>et al.</i> (2019)  |
| HF × Borena (75% F <sub>1</sub> ) | 243.03 ± 14.39         | Getahun <i>et al.</i> (2019)  |
| HF × Borena (75% F <sub>2</sub> ) | 108.55 ± 33.45         | Getahun <i>et al.</i> (2019)  |
| HF × Local (West Shoa)            | 122.4 ± 5.2            | Megersa (2016)                |
| Pure Local (West Shoa)            | 216.9 ± 2              | Megersa (2016)                |
| HF 50% (Walmera)                  | 5.70 ± 1.42            | Ketema <i>et al.</i> (2018)   |
| HF >50% (Walmera)                 | 4.75 ± 1.12            | Ketema <i>et al.</i> (2018)   |
| Pure Local (Walmera)              | 7.64 ± 2.65            | Ketema <i>et al.</i> (2018)   |
| HF × Local (West Shoa)            | 113.08 ± 0.31          | Bayissa <i>et al.</i> (2017)  |
| Pure Local (West Shoa)            | 191.40 ± 0.35          | Bayissa <i>et al.</i> (2017)  |

#### 2.1.5. *Number of services per conception (NPC)*

NSC is the number of days between the first insemination and positive pregnancy diagnosis. The number of services per conception (NSC) is the number of services (natural or artificial), required for successful conception. It is a good measure of the fertility status of dairy herds. It is reflecting the efficiency of management. The number of inseminations required to produce a live calf is one of the most useful parameters of reproductive efficiency which mainly depends on the breeding system used. One of the most important measures of reproductive efficiency is the number of inseminations required to deliver a live calf, which is heavily depends on the breeding strategy used. Haile *et al.* (2008) reported that values of the number of services per conception (NPC) greater than 2 should be regarded as poor.

Breeds or level of exotic blood, parity, season and period of calving have effect on the number of services per conception. Excellent herd management and performance of cows can be associated with lowest services per conception. Cows with higher milk yields are known not to breed quickly, have longer service periods and take a long time to conceive. Heifers/cows that calved during the long dry season require more services per conception, while those that calved during the long rain season had lower services per conception. Poor nutrition has often been a limiting factor to dairy cattle performance particularly in the long dry season when nutritive value of pasture is very low. Insufficiency or an imbalance of protein, energy, roughage, vitamins and minerals do result in repeat breeders as well as low ovarian activity. The predicted mean of number of services per conception for the dairy herds reported by different authors are shown are in Table 4.

Table 4. Number of services per conception (NPC) for dairy cows in Ethiopia

| <b>Breed</b>                      | <b>NPC(No)</b> | <b>Sources</b>                |
|-----------------------------------|----------------|-------------------------------|
| Arsi                              | 2.4 ± 0.2      | Azage (2000)                  |
| Barka                             | 1.6 ± 0.74     | Azage (2000)                  |
| Borena                            | 2.17 ± 0.31    | Meseret <i>et al.</i> (2014)  |
| Horro                             | 2.00 ± 0.35    | Gizaw <i>et al.</i> (2011)    |
| Fogera                            | 1.42 ± 0.05    | Assemu <i>et al.</i> (2016)   |
| HF× Arsi                          | 1.39 ± 0.05    | Wassie <i>et al.</i> (2015)   |
| HF × Borena                       | 1.32 ± 0.06    | Wassie <i>et al.</i> (2015)   |
| Friesian × Borena                 | 2.4 ± 0.13     | Haile <i>et al.</i> (2009b)   |
| Friesian × Horro                  | 1.69 ± 0.1     | Sisay (2015)                  |
| Jersey × Horro                    | 1.75 ± 0.1     | Sisay (2015)                  |
| HF × Fogera                       | 1.54 ± 0.1     | Gebeyehu <i>et al.</i> (2005) |
| HF × Zebu (50%)                   | 2.2 ± 0.10     | Haile <i>et al.</i> (2009b)   |
| HF × Zebu (62.5%)                 | 2.7 ± 0.18     | Haile <i>et al.</i> (2009b)   |
| HF × Zebu (75%)                   | 2.2 ± 0.17     | Haile <i>et al.</i> (2009b)   |
| HF × Zebu (87.5%)                 | 1.7 ± 0.11     | Haile <i>et al.</i> (2009b)   |
| F <sub>1</sub> Jersey             | 1.59±4         | Kefena <i>et al.</i> (2006a)  |
| F <sub>2</sub> Friesian           | 1.4±4          | Kefena <i>et al.</i> (2006a)  |
| F <sub>2</sub> Jersey             | 1.68±4         | Kefena <i>et al.</i> (2006a)  |
| 75% Friesian                      | 1.59±5         | Kefena <i>et al.</i> (2006a)  |
| 75% Jersey                        | 1.23±2         | Kefena <i>et al.</i> (2006a)  |
| HF × Borena (50% F <sub>1</sub> ) | 1.64 ± 0.04    | Getahun <i>et al.</i> (2019)  |
| HF × Borena (50% F <sub>2</sub> ) | 1.79 ± 0.09    | Getahun <i>et al.</i> (2019)  |
| HF × Borena (50% F <sub>3</sub> ) | 1.84 ± 0.11    | Getahun <i>et al.</i> (2019)  |
| HF × Borena (75% F <sub>1</sub> ) | 1.97 ± 0.09    | Getahun <i>et al.</i> (2019)  |
| HF × Borena (75% F <sub>1</sub> ) | 1.33 ± 0.19    | Getahun <i>et al.</i> (2019)  |
| HF × Local (West Shoa)            | 2.14 ± 0.09    | Megersa (2016)                |
| Pure Local (West Shoa)            | 3.3 ± 0.09     | Megersa (2016)                |

### 3. MATERIALS AND METHODS

The present studies were conducted at on-farm and on-station sites. An on-farm study was conducted in three selected districts of West Shoa Zone, whereas the on-station study was conducted at Holeta Agricultural Research Centers' (HARC) dairy farm, Ethiopia.

#### 3.1. On Station Study

##### 3.1.1. Description of study centers

The on-station study was conducted at the Holeta Agricultural Research Centers' (HARC) dairy farm, located 29 km west of Addis Ababa.

Holeta is geographically located in the central highlands of Ethiopia at a longitude of 38° 30' E and latitude, 9° 00' N with an altitude of 2400 meter above sea level. The mean annual minimum and a maximum temperature range from 6 to 22°C, respectively. The area has a mean annual rainfall of 1144 mm. The area experiences three major seasons, wet (June to September), short rain (March to May), dry (October to February). The soil types in the area are nitisol and vertosols. The major crops grown are tef, wheat, barley, oats, potatoes, oil crops and pulses.

##### 3.1.2. Data collection and data source

Data of all cows recorded in the history sheet kept on each animal record book kept at the HARC dairy farm was used to illustrate the fertility status and lactation performance. Data used for this study obtained from a long-term (1976-2019) research record book of dairy herds of Ethiopian pure Borena, Borena × Holstein Friesian and Jersey crossbred cattle kept at the research station; thus, Borena and different crossbred ranging from 50% to 75% HF and Jersey blood were used in the study. The following information were gathered from individual animal card history and the center database for traits analysis. Animal identification number, date of birth, days open, age at first service, number of services per conception, age at first calving, calving intervals, daily milk yield, lactation period, and total lactation milk yield, parity, genetic group, sire of cow and dam of cow were all factors to be considered.

Based on climatic condition and weather of the area, seasons of the year was divided into three seasons that is, a dry season (October to February), a short rainy season (March to May), and a long rainy season (June to September). The following dependent variables were extracted from the collected information: Age at first service (AFS), age at first calving (AFC), calving intervals (CI),

days Open (DO), number of services per conception (NSC), Lactation Length (LL), daily milk yield (DMY) and lactation milk yield (LMY). Only herds with valid reproductive and milk production records were included in the study.

### *3.1.3. Herd management*

Animals were kept under intensive systems of feeding and production and herds were separately managed based on sex, age, pregnancy, calving period, and lactation. The regular conditions of feeding and management practices were adopted for all animals. Natural pasture, hay and concentrate supplement constitute the major feed supply. Animals were individually fed to the stall with green fodders and roughages, concentrates are a supplemented to the animals based on the level of production and the animals' maintenance requirements. The concentrate mixture composed of wheat middling (32%), wheat bran (32%), noug cake (34%), and salt (2%) was supplemented based on their body weight, productivity and physiological categories. Milking cows, heifers and calves were supplemented with concentrate mixture at a rate of 4kg, 1-1.5 and 0.25-1kg per day, respectively. The concentrate mixture had 81.0% DM, 29.5% crude protein, 46.9% neutral detergent fiber and 71.8% digestible organic matter. All the time, the cows had free access to clean tap water.

Newborn calves were allowed to suckle their dam immediately after birth for about four days to receive colostrum's. Weighting and ear tagging were also engaged within 24 hours after birth. After 4 days calves were taken in to calf rearing pen and continued to fed a fixed amount of (260 liters of whole milk) milk for 98 days through artificial rearing system (bucket feeding) except the F1 calves which have suckled their dams up until winning since 2002. Weaned calves were transferred to other pen and kept indoor up until 6 months of age.

The daily milk yield had been recorded for individual animals. Milking has been practiced by hand. In 2002 milking machine has been installed with the aid of ARTP. Since then, cows have been milked with milking machine twice daily (early morning and evening). Selection procedure based on phenotypic performance and breeding value was practiced since 2005. Except for candidate bulls which were recruited for semen production, all unwanted male calves and unproductive animals were culled from the farm.

Treatment of the herd against any incidence of diseases was a routine practice. Seasonal outbreaks of major diseases of economic importance were identified and control measures have been

undertaken according to the disease control calendar set by the animal health research division of the HARC. Animals were routinely vaccinated against anthrax, pasteurellosis, blackleg, lumpy skin disease, foot, and mouth disease, and infectious bovine pleuro-pneumonia. Both internal and external parasitic infestations are routinely dewormed and sprayed.

#### *3.1.4. Breeding program and study animals*

HARC dairy farm started in 1966 with a foundation stock of Holstein Friesian, pure Borena, Simmental, and Jersey. For many years, purebred Borena have been crossed with Friesian, Jersey, and Simmental breeds, resulting in diverse genetic groupings in the herd. Simmental crossbreeding operations were unfortunately discontinued. As a result, data from pure Borena, Borena × HF and Jersey crossbreds were used in the study. The Borena × HF and Jersey mating systems were generated distinct genetic groups (50% F<sub>1</sub>, F<sub>2</sub>, F<sub>3</sub>, and few attempts were on high-grade of 62.5%, 75%, and 87.5%). Therefore, the present study concentrated on pure Borena, 50% F<sub>1</sub>, F<sub>2</sub>, F<sub>3</sub>, 75% F<sub>1</sub>, and F<sub>2</sub> generations.

The 50% F<sub>1</sub> crosses were produced by mating pure Borena dams with pure Friesian semen, while the 75 % first generation was produced by back crossing the 50% F<sub>1</sub> with pure Friesian semen. Later generations (F<sub>2</sub> and F<sub>3</sub>) were produced by inter-crossing 50% males with 50% females and 75% males with 75% females, respectively, to generate synthetic breeds with 50% HF and 50% Borena blood levels and 75% HF and 25% Borena blood levels. Borena cattle were purchased from their center of origin, Borena pastoralists in southern Ethiopia and reared on station before being mated at random with NAIC Kality and WWS semen to create the requisite generations.

Artificial insemination, obtained from locally recruited crossbred bulls or pure Friesian or Jersey semen from NAIC Kality, Worldwide sires, was used throughout the year on the farm, and sometimes natural service was used when animals not conceive with AI. Bulls born on the farm were selected for breeding based on dam milk performance and physical conformation for semen collection in NAIC and on-station breeding activities, with special care given to avoid genetic relationships during bull selection for NAIC. The research station is recently working on selecting bulls based on their breeding value. Since 2010, a new activity at Holetta Agricultural Research Centre (HARC) has been initiated to cross breeding Borena cows with exotic Frisian bulls using Worldwide sire (WWS) imported semen by ALPPIS for further improvement, selection, and milk production.

Estrus detection is conducted early in the morning and late in the afternoon. Cows that were found to be in heat were artificially mated by trained technicians. The on-station selection program, which comprised 50% of Friesian × Borena F<sub>1</sub> cows and 75% of crossed cows and bulls, likely started in 2005. Selection generated adequate information to maintain a superior genotype for the future generation of crossbred dairy cows.

### *3.1.5. Data management*

To avoid manmade errors during data entry on individual animal cards or computer writing, data screening was done. As a result, data that did not accurately reflect the study population (the herd) had to be removed before final analysis, possibly resulting in biased estimates. Lactation lengths of below 90 days were removed from the data set during data clearing, because they were considered incomplete lactation for analysis of lactation milk yield and daily milk yield. Similarly, data clearing was applied on age at first service (AFS) below 10 months and above 80 months, as well as age at first calving (AFC) below 20 months and above 90 months.

Cows have an average gestation period of 285 days and a voluntary wait period of 45 days post-natal (330-day CI). Cows with a calving interval (CI) of less than 330 days were excluded from the study. After calving cow must rest for some time to allow the uterus to involute and the normal cycle to take place. As a result, before the cow was inseminated or bred, a voluntary waiting period (VWP) of 45 to 60 days was allowed (Gebregziabher *et al.*, 2005). Therefore, animals that had shown estrus and had been bred before 45 days were excluded from the analysis. Repeat breeder cows that had been bred more than ten times were rare in comparison to the rest of the population and they were removed.

## **3.2. On-Farm Study**

### *3.2.1. Description of study areas*

Assessment of on-farm fertility status of dairy herds was conducted in three districts of West Shoa Zone, Ada'a Berga, Ambo, and Walmera woredas of Oromia region, Ethiopia.

Ada'a Berga located between 9°12" to 9°37"N and 38°17" to 38°36"E and about 107 km northeast of zonal town Ambo and 60 km west of Addis Ababa. The mean annual rainfall of the district is 1290 mm and the mean annual minimum and maximum temperatures, respectively, lie between

12°C and 25°C. The altitude the ranges from 1166 to 3238 meter above sea level. The agricultural production system in the study area is of mixed crop and livestock production.

Ambo woreda is located 114 km away west of Addis Ababa lying between 8°47" to 9°21" North latitude and 37°32" to 38°3" East longitude with the altitude of 2100 meter above sea level. The main rainy season is the period from June-September and the short rainy season is the period from March to the end of April. Mean annual rainfall is ranging from 1600 to 500 mm. The maximum and minimum temperature ranges from 10 to 28 °C.

Walmera is located 35km to the west of Addis Ababa along the main road to Ambo. Geographically, the district is found at 9°0' 0' to 9° 10' 0' N latitude and 38°25'0' to 38°30'0' E longitudes. The study area has an altitude of 2400 meter above sea level and receives an average annual rainfall of about 1100mm. The mean minimum and maximum temperatures, respectively, are 6 and 24 °C (WDLDFO, 2017). The area obtains a short rainy season (March to May), long rainy season (June to September), and dry season (October to February).

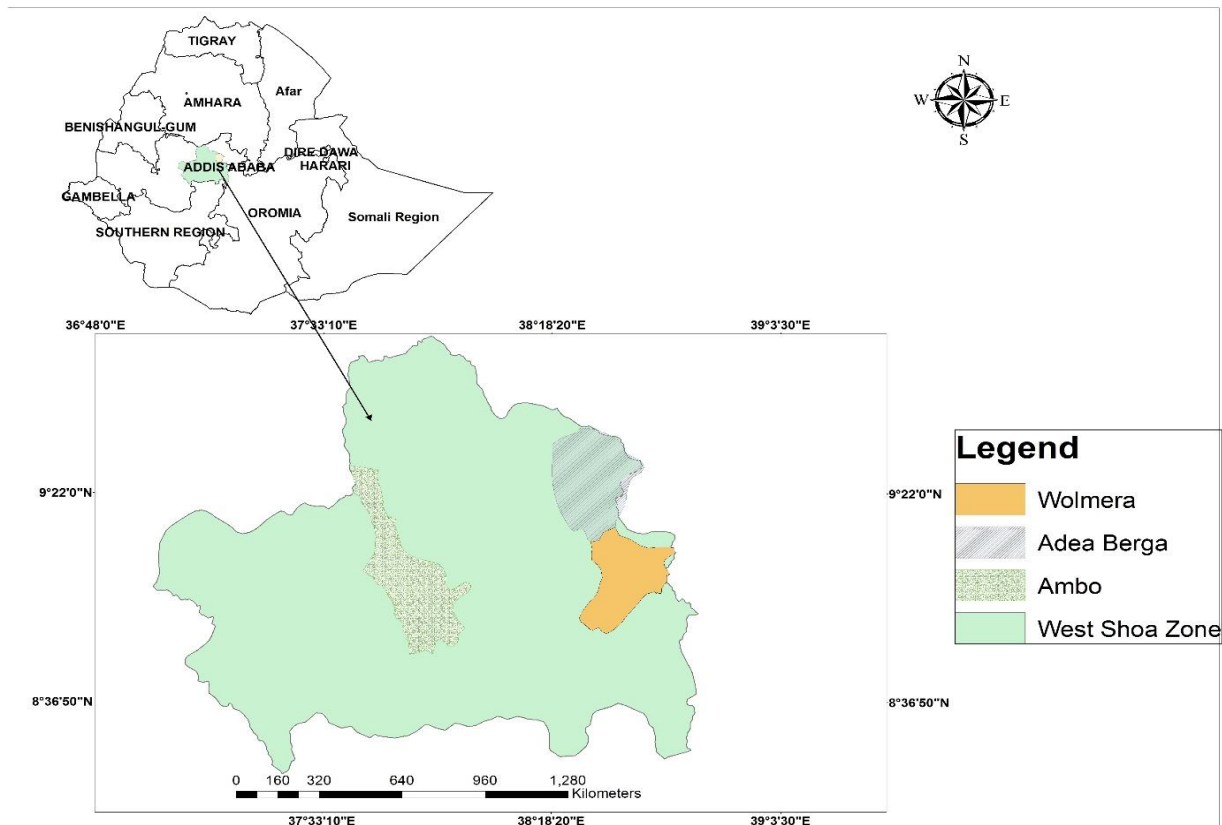


Figure 1. Map of the study areas, West Shoa Zone, Ethiopia.

### 3.2.2. *Sample size and sampling procedures*

Semi-structured questionnaires were used to gather information from dairy producers under smallholder conditions in a single visit interview to study the fertility status of their dairy cows in three selected districts of the West Shoa zones. The questionnaire was developed to meet the study's objectives and was thoroughly structured to acquire specific information from respondents. The questionnaires were tested before the interview to see whether the questions are clear. A brief overview of the nature and purpose of the study was given to each respondent. The questions were asked in a very clear manner whenever appropriate, and the responses were recorded immediately on the survey schedule. Accordingly, information about household's characteristics, dairy management practices, breeding practices, the fertility and productive traits (age at first service and calving, calving intervals, days open till conception, the number of services per conception and daily milk yield, lactation period, lactation milk yield) were collected. Information about fertility disorders like abortion, retained placenta, stillbirth, calf mortality, anestrus, repeat breeding and possible causes of these factors were collected.

The three districts were purposively selected, from the West Shoa Zone, based on the availability of dairy technologies and the population of dairy cows. A simple random sampling procedure was implemented to identify dairy farms and individual's dairy cows producers based on milk production potentials and dairy technologies accessibility. Individual dairy cow producers were randomly selected from the list for an interview. The target population was defined as farmers who are living in a similar area and those who had equal access to dairy technologies. A total of 12 kebeles, three from each district was selected by systematic sampling based on the same criteria employed for the selection of districts. A total of 180 samples of households (HH) (15 from each kebele and 60 from each district) were selected. Sample size was determined using the formula given by Arsham (2007) for survey studies:

$$N = 0.25/SE^2$$

Where N = sample size

SE= Standard error of the population.

### 3.3. Data Analysis

The data on fertility traits (AFS, AFC, CI, DO, and NSC) and productive traits (daily milk yield, lactation length, and lactation milk yield) of dairy herds obtained from the recorded sheet at HARC' dairy farm and the interview of smallholder dairy producers were entered and managed into Microsoft excel 2019 spreadsheet. The collected survey data was analyzed using Statistical Packages for the Social Sciences (SPSS) version 26. Descriptive statistics cross-tabulation such as percentage, mean, and standard deviation were used to present the results. The collected data from the recorded sheet at HARC's dairy herds was analyzed by using General Linear Model (GLM) procedures of SAS version 9.2 (SAS, 2008). The model included fixed effects of breeds of cows/sires, season, parity, and year of calving (1976-2019 G.C). The year is divided into three seasons based on rainfall distribution: a dry season (October to February), a short rain season (March to May), and wet seasons (June to September).

Based on the exotic blood levels, the genetic group enrolled in the analysis was classified into two parts (50% F<sub>1</sub>, F<sub>2</sub>, F<sub>3</sub> and 75% F<sub>1</sub>, F<sub>2</sub>). The Borena breed had no selection or improvement because it has only been used as a dam line for F<sub>1</sub> generations.

**Model 1:** The NSC was analyzed using the following model.

$$Y_{ijkln} = \mu + Y_i + S_j + G_k + P_l + e_{ijkl}$$

This model also employed for the analysis of days open, calving intervals, daily milk yield, lactation length and lactation milk yield.

$Y_{ijkl}$ : the observations on each trait

$\mu$ : overall mean

$Y_i$ : effect of  $i^{\text{th}}$  year of calving

$S_j$ : effect of  $j^{\text{th}}$  season of calving (dry, October to February; short rain, March to May and long rainy season, June to September).

$G_k$ : effect of the  $k^{\text{th}}$  genetic group (pure Borena, 50% F<sub>1</sub>, F<sub>2</sub>, F<sub>3</sub>, and 75% F<sub>1</sub>, F<sub>2</sub> HF, and Jersey)

$P_l$ : effect of parity of the dam (1, 2, 3, 4, 5, 6, 7, 8,9,10)

$e_{ijk}$ : random error associated with each observation

**Model 2:** AFS was analyzed using the following model.

$$Y_{ijk} = \mu + Y_i + S_j + G_k + e_{ijk}$$

This model also employed for the analysis AFC.

$Y_{ijk}$ : the observation on AFS and AFC.

$\mu$ : overall mean

$Y_i$ : effect of  $i^{\text{th}}$  year of birth

$S_j$ : effect of  $j^{\text{th}}$  season of calving (dry, wet and short rainy season)

$G_k$ : effect of the  $k^{\text{th}}$  genetic group

$e_{ijk}$ : random residual error

Table 5. Number of records used for fixed effects and genetic group analysis.

| Traits | Genetic group  |                    |                |                |                |                |                        |                |                |                |     | Total |
|--------|----------------|--------------------|----------------|----------------|----------------|----------------|------------------------|----------------|----------------|----------------|-----|-------|
|        | Borena         | Borena $\times$ HF |                |                |                |                | Borena $\times$ Jersey |                |                |                |     |       |
|        | Pure Borena    | 50%                |                |                | 75%            |                | 50%                    |                |                | 75%            |     |       |
|        | F <sub>1</sub> | F <sub>2</sub>     | F <sub>3</sub> | F <sub>1</sub> | F <sub>2</sub> | F <sub>1</sub> | F <sub>2</sub>         | F <sub>3</sub> | F <sub>1</sub> | F <sub>2</sub> |     |       |
| AFS    | 247            | 382                | 84             | 53             | 166            | 64             | 128                    | 38             | 25             | 95             | 22  | 1304  |
| AFC    | 248            | 388                | 84             | 53             | 166            | 64             | 130                    | 42             | 25             | 95             | 22  | 1317  |
| CI     | 1410           | 1974               | 269            | 161            | 436            | 73             | 528                    | 223            | 62             | 180            | 92  | 5408  |
| DO     | 1405           | 1971               | 264            | 160            | 432            | 72             | 526                    | 221            | 61             | 176            | 92  | 5380  |
| NSC    | 1419           | 2000               | 272            | 161            | 444            | 68             | 629                    | 226            | 63             | 111            | 98  | 5490  |
| DMY    | 1371           | 1212               | 205            | 128            | 181            | 50             | 414                    | 160            | 46             | 83             | 38  | 3888  |
| LL     | 1371           | 1212               | 205            | 128            | 181            | 50             | 414                    | 160            | 46             | 83             | 38  | 3888  |
| LMY    | 1462           | 1394               | 261            | 159            | 180            | 69             | 426                    | 147            | 59             | 99             | 44  | 4300  |
| Total  | 8933           | 10533              | 1644           | 1002           | 2186           | 510            | 3195                   | 1217           | 387            | 922            | 446 | 30975 |

$F_1 =$  first filial generation,  $F_2 =$  second filial generation,  $F_3 =$  third filial generation

## 4. RESULTS

### 4.1. On-Station Study

#### 4.1.1. Fertility traits

Fertility traits are one of the most important issues in livestock production. Traits like AFS, AFC, CI, DO, and NSC can all be used to evaluate fertility.

##### 4.1.1.1. Age at first service (AFS)

The Least square mean ( $\pm$ SE) for fixed effects of genetic group, birth year group, and birth season group on AFS are summarized in (Table 6). The overall least square mean ( $\pm$ SE) for eleven genetic groups of AFS was  $29.98 \pm 10.23$  months and ranged from  $25.34 \pm 0.45$  to  $43.30 \pm 1.68$  months.

The fixed effects of genetic group and birth year had a highly significant ( $P < 0.0001$ ) effect on AFS (Appendix Table 1). In this study, for Borena  $\times$  HF and Jersey crosses the longest and shortest values found, respectively, were  $35.85 \pm 1.23$  and  $25.34 \pm 0.45$  months and  $37.95 \pm 1.72$  and  $28.43 \pm 3.29$  months. AFS significantly ( $P < 0.0001$ ) increased by 2.04 months from 50%  $F_1$  to 75%  $F_1$  crosses of HF  $\times$  Borena whereas increased by 3.29 months from 50%  $F_1$  to 75%  $F_1$  crosses of Jersey  $\times$  Borena. The adjusted least square mean for pure Borena of AFS was  $35.43 \pm 1.00$  months.

In current study (Figure 2), the longest ( $43.30 \pm 1.68$  months) AFS was observed in animals born between 1976 and 1981 whereas the shortest ( $26.35 \pm 0.48$  months) AFS was scored in animals born during 2012 to 2017. Birth season had no significant effect on AFS.

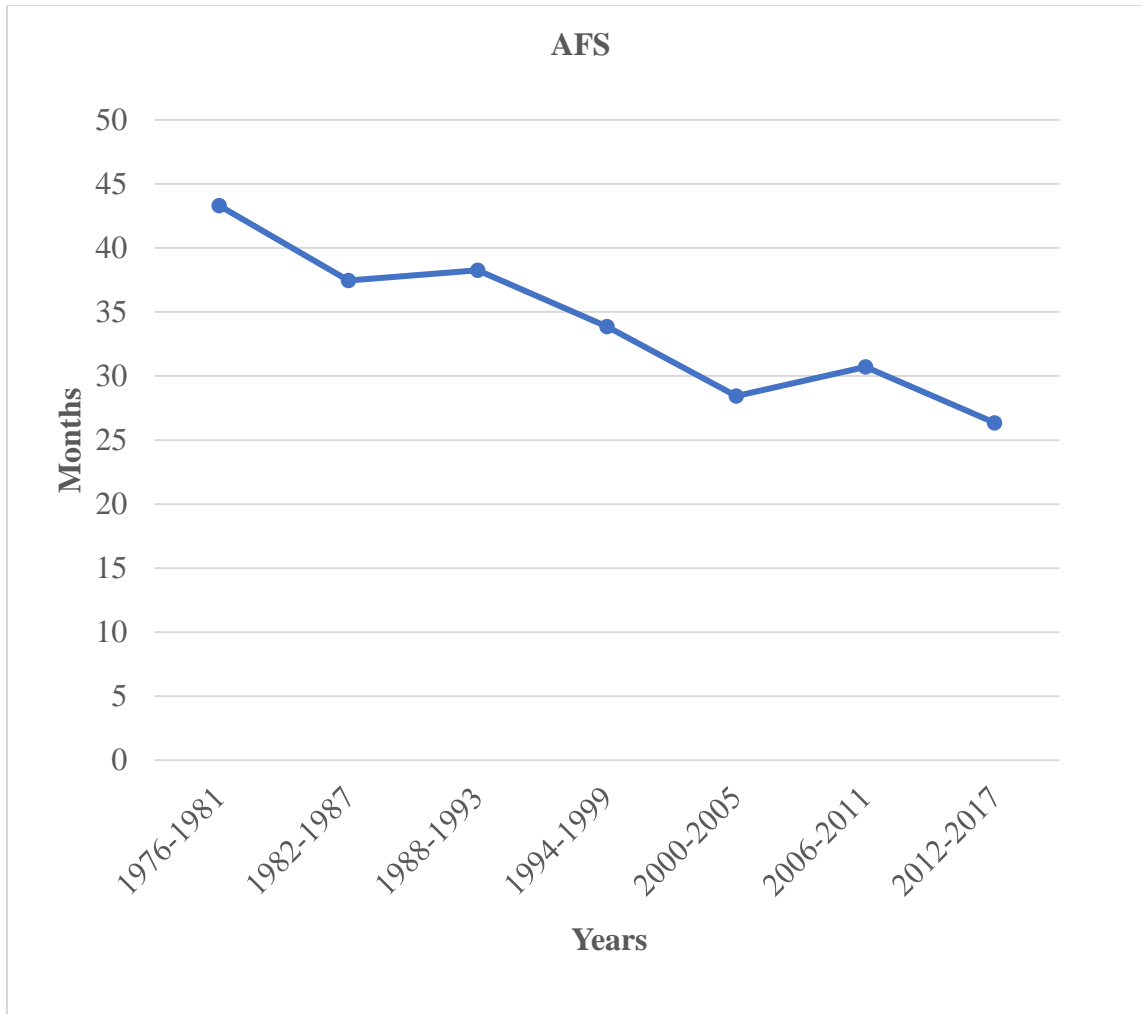


Figure 2. The trend of age at first service (AFS) over year of birth

#### 4.1.1.2. Age at first calving (AFC)

The least square mean ( $\pm$ SE) for fixed effects of genetic group, birth year and birth season on age at first calving are presented in (Table 6). The overall least square mean ( $\pm$ SE) for Borena  $\times$  HF and Jersey and pure Borena of AFC was  $39.16 \pm 8.58$  months in the range between  $34.18 \pm 0.70$  to  $46.96 \pm 1.60$  months.

The fixed effects genetic group and birth year had a highly significant ( $P < 0.0001$ ) effect on AFC trait. The 50% F<sub>1</sub> and 75% F<sub>2</sub> had significantly ( $P < 0.0001$ ) shorter ( $34.47 \pm 0.46$  and  $34.18 \pm 0.70$  months) AFC and 50% F<sub>2</sub> had longer ( $44.21 \pm 1.09$  months) AFC for HF  $\times$  Borena whereas 50% F<sub>3</sub> had significantly ( $P < 0.0001$ ) shorter ( $37.09 \pm 2.39$  months) AFC and 50% F<sub>2</sub> had longer ( $46.96 \pm 1.80$  months) AFC recorded for Jersey  $\times$  Borena crosses. AFC was increased by 3.2 months

from 50% F<sub>1</sub> to 75% F<sub>1</sub> and decreased by 3.5 months from 50% F<sub>1</sub> to 50% F<sub>2</sub> of Jersey × Borena crosses. The least square mean for pure Borena heifers of AFC was 45.44 ± 0.70 months.

Trend analysis of AFC based on birth year shown that animals born in 2012 to 2017 had significantly (P<0.0001) shortest (34.84 ± 0.44 months) value while animals born 1976 to 1981 have been scored longest (52.14 ± 1.60 months) value. Season of birth had no significant effect on age at first calving of heifers.

Table 6. Least square means (±SE) of AFS and AFC

| Fixed effects             | AFS (months) |                             | AFC (months) |                            |
|---------------------------|--------------|-----------------------------|--------------|----------------------------|
|                           | N            | LSM ± SE                    | N            | LSM ± SE                   |
| <b>Overall</b>            | 1304         | 29.98 ± 10.23               | 1317         | 39.16 ± 8.58               |
| <b>CV (%)</b>             |              | 27.19                       |              | 21.90                      |
| <b>Genetic group</b>      |              | <b>P&lt;0.0001</b>          |              | <b>P&lt;0.0001</b>         |
| Pure Borena               | 247          | 35.43 <sup>a</sup> ± 1.00   | 248          | 45.44 <sup>a</sup> ± 0.70  |
| <b>Borena × HF</b>        |              |                             |              |                            |
| 50% F <sub>1</sub>        | 382          | 25.34 <sup>d</sup> ± 0.45   | 388          | 34.47 <sup>c</sup> ± 0.46  |
| 50% F <sub>2</sub>        | 84           | 35.85 <sup>a</sup> ± 1.23   | 84           | 44.21 <sup>a</sup> ± 1.09  |
| 50% F <sub>3</sub>        | 53           | 33.36 <sup>abc</sup> ± 1.40 | 53           | 42.48 <sup>ab</sup> ± 1.43 |
| 75% F <sub>1</sub>        | 166          | 27.38 <sup>d</sup> ± 0.65   | 166          | 35.91 <sup>c</sup> ± 0.64  |
| 75% F <sub>2</sub>        | 64           | 25.78 <sup>d</sup> ± 0.78   | 64           | 34.18 <sup>c</sup> ± 0.70  |
| <b>Borena × Jersey</b>    |              |                             |              |                            |
| 50% F <sub>1</sub>        | 128          | 33.87 <sup>ab</sup> ± 1.91  | 130          | 43.46 <sup>a</sup> ± 1.76  |
| 50% F <sub>2</sub>        | 38           | 37.95 <sup>a</sup> ± 1.72   | 42           | 46.96 <sup>a</sup> ± 1.80  |
| 50% F <sub>3</sub>        | 25           | 28.97 <sup>cd</sup> ± 1.91  | 25           | 37.09 <sup>c</sup> ± 2.39  |
| 75% F <sub>1</sub>        | 95           | 37.16 <sup>d</sup> ± 3.35   | 95           | 46.67 <sup>a</sup> ± 3.20  |
| 75% F <sub>2</sub>        | 22           | 28.43 <sup>bcd</sup> ± 3.29 | 22           | 38.71 <sup>bc</sup> ± 3.20 |
| <b>Birth Year group</b>   |              | <b>P&lt;0.0001</b>          |              | <b>P&lt;0.0001</b>         |
| 1976-1981                 | 80           | 43.30 <sup>a</sup> ± 1.68   | 70           | 52.14 <sup>a</sup> ± 1.60  |
| 1982-1987                 | 76           | 37.45 <sup>b</sup> ± 2.10   | 66           | 47.94 <sup>b</sup> ± 1.97  |
| 1988-1993                 | 72           | 38.27 <sup>b</sup> ± 1.54   | 62           | 47.68 <sup>b</sup> ± 1.64  |
| 1994-1999                 | 166          | 33.86 <sup>c</sup> ± 0.87   | 168          | 42.89 <sup>c</sup> ± 0.89  |
| 2000-2005                 | 277          | 28.43 <sup>de</sup> ± 0.66  | 200          | 37.55 <sup>d</sup> ± 0.66  |
| 2006-2011                 | 319          | 30.72 <sup>d</sup> ± 1.23   | 261          | 41.27 <sup>c</sup> ± 0.65  |
| 2012-2017                 | 314          | 26.35 <sup>ef</sup> ± 0.48  | 258          | 34.84 <sup>e</sup> ± 0.44  |
| <b>Birth Season group</b> |              | <b>NS</b>                   |              | <b>NS</b>                  |
| Dry Season                | 617          | 29.50 ± 0.54                | 622          | 38.87 ± 0.44               |
| Short Rain                | 369          | 30.93 ± 0.89                | 374          | 39.73 ± 0.66               |
| Long rain                 | 318          | 30.06 ± 0.66                | 321          | 39.18 ± 0.68               |

❖ *Superscripts<sup>a, b, c, d, e</sup> in the same fixed effect indicates differences among sample means,*

*NS= not significant.*

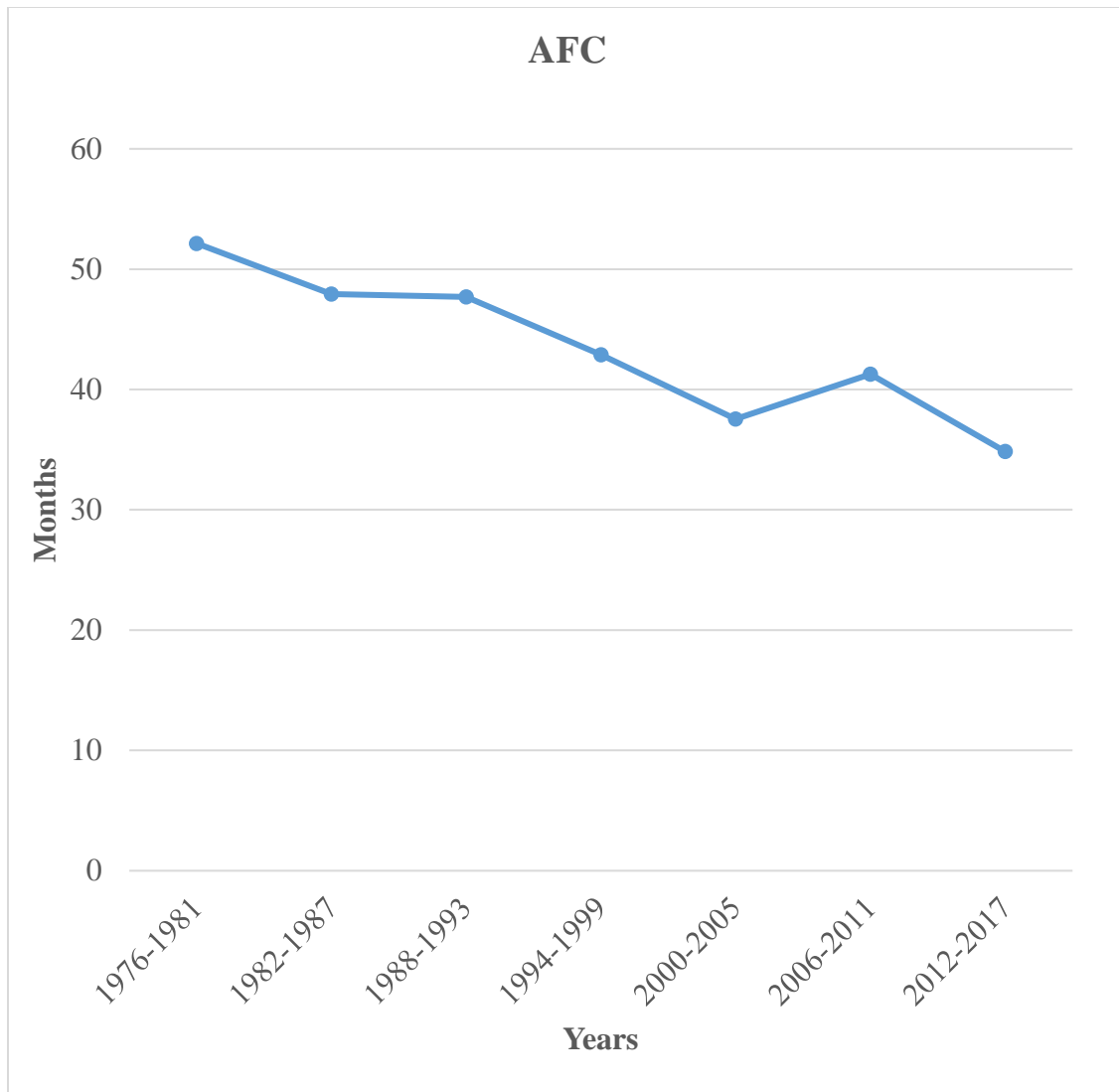


Figure 3. The trend of age at first calving (AFC) over year of birth.

#### 4.1.1.3. Calving intervals (CI)

The least square mean ( $\pm$ SE) for fixed effects of genetic group, calving year group, season of calving and parity on calving intervals traits are indicated in (Table 7). The overall least square mean ( $\pm$ SE) of pure Borena, Borena  $\times$  HF and Jersey was estimated to be  $496.24 \pm 42.19$  days ( $16.54 \pm 1.41$  months).

For HF  $\times$  Borena crosses, the longest ( $540.30 \pm 10.48$  days or  $17.78 \pm 0.35$  months) calving intervals was obtained from 50% F<sub>2</sub> and the shortest ( $466.78 \pm 3.10$  days or  $15.36 \pm 0.10$  months) was from 50% F<sub>1</sub> crosses. For Jersey  $\times$  Borena crosses, the longest ( $515.97 \pm 15.36$  days or  $16.97 \pm 0.51$  months) CI was obtained from 75% F<sub>1</sub> and the shortest ( $498.11 \pm 59.42$  days or  $16.39 \pm$

1.95 months) was recorded in 75% F<sub>2</sub>. For HF × Borena crosses, the calving interval was increased by 74 days between 50% F<sub>1</sub> and F<sub>2</sub> and by 60 days from 50% F<sub>1</sub> to 75% F<sub>1</sub> genetic group. The adjusted least square mean (±SE) for calving intervals of pure Borena dairy cows was 513.29 ± 3.77 days (17.11 ± 0.13 months).

In this study, calving year of cows had a highly significant (P<0.0001) effect on calving intervals trait (Appendix Table 3). Shortest (444.82 ± 3.54 days) calving intervals was recorded in animals calved between 2010 to 2014 whereas the longest (568.64a ± 12.26 days) calving interval was observed during 1985 to 1989 (Figure 4).

As shown in the least square mean analysis there was no significant difference has observed between dry season, short and long rainy season. In parity two and parity ten, respectively, the highest (525.62 ± 5.07 days) and lowest (423.11 ± 14.37 days) values of calving intervals was observed. Statistically there was no significant difference observed from 3<sup>rd</sup> to 9<sup>th</sup> parities. In the current study as parity increased CI was decreased.

#### 4.1.1.4. Days open (DO)

The least squares mean (±SE) for fixed effects of genetic group, calving year, calving season and parity are listed in (Table 7). In the current study, the overall least square mean (±SE) for pure Borena, Borena × HF and Jersey of days open was 216.81 ± 41.72 days.

Days open trait was significantly affected by fixed effects of genetic group, calving year group and parity (Appendix Table 7). For HF × Borena crosses, the highest (261.07 ± 10.44 days) and lowest (186.99 ± 3.08 days) values of DO, respectively, were recorded on 50% F<sub>2</sub> and 50% F<sub>1</sub> crosses whereas for Jersey × Borena the highest (232.29 ± 11.2 days) and lowest (213.44 ± 8.23 days) values of DO, respectively, were observed on 50% F<sub>2</sub> and 75% F<sub>2</sub> crosses. The 50% F<sub>1</sub> crosses had return to conception 74 days and 45 days, respectively, earlier than 50% F<sub>2</sub> and 75% F<sub>1</sub> for HF × Borena crosses. For this trait, the 50% F<sub>1</sub> and 50% F<sub>3</sub> of HF × Borena crosses whereas the 50% F<sub>3</sub> and 75% F<sub>2</sub> genotype of Jersey × Borena crosses have shown better performance. The adjusted mean for Pure Borena dairy cows of days open was 235.50 ± 3.78 days.

Animals calved between 2010 to 2014 had recorded shortest days open whereas the longest days open was observed during 1985 to 1989 (Figure 4). In this study as shown in the least square mean, days open was not influenced by season.

Parity of cows had a highly significant ( $P < 0.0001$ ) effect on the days open trait. The higher days open was significantly observed at the 2<sup>nd</sup> parity than the rest parities. Cows in their 2<sup>nd</sup> parity required 45 more days than the optimum days open and 102 more days than 10<sup>th</sup> parity.

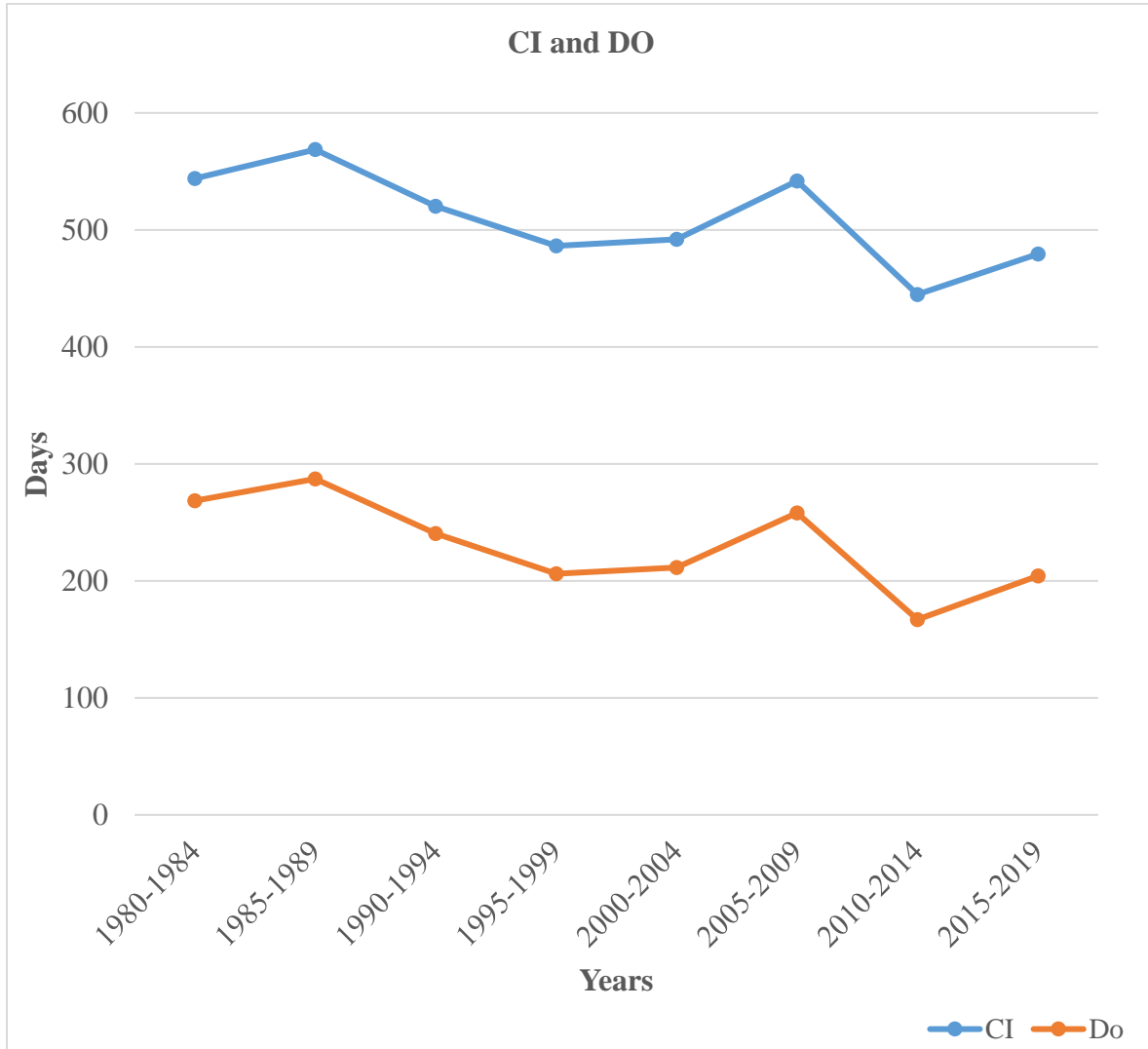


Figure 4. The trend of calving intervals (CI) and days open (DO) over year of calving.

Table 7. Least Square means ( $\pm$ SE) of CI and DO

| Fixed effects                            | CI (Days) |                                  | DO (Days) |                                  |
|--|-----------|----------------------------------|-----------|----------------------------------|
|  | N         | LSM $\pm$ SE                     | N         | LSM $\pm$ SE                     |
| <b>Overall</b>                           | 5408      | 496.24 $\pm$ 42.19               | 5380      | 216.81 $\pm$ 41.72               |
| <b>CV (%)</b>                            |           | 28.65                            |           | 23.11                            |
| <b>Genetic group</b>                     |           | <b>P&lt;0.0001</b>               |           | <b>P&lt;0.0001</b>               |
| Pure Borena                              | 1410      | 513.29 <sup>ab</sup> $\pm$ 3.77  | 1405      | 235.50 <sup>ab</sup> $\pm$ 3.78  |
| <b>Borena <math>\times</math> HF</b>     |           |                                  |           |                                  |
| 50% F <sub>1</sub>                       | 1974      | 466.78 <sup>b</sup> $\pm$ 3.10   | 1971      | 186.99 <sup>b</sup> $\pm$ 3.08   |
| 50% F <sub>2</sub>                       | 269       | 540.30 <sup>a</sup> $\pm$ 10.48  | 264       | 261.07 <sup>a</sup> $\pm$ 10.44  |
| 50% F <sub>3</sub>                       | 161       | 495.69 <sup>b</sup> $\pm$ 11.89  | 160       | 215.94 <sup>ab</sup> $\pm$ 11.89 |
| 75% F <sub>1</sub>                       | 436       | 527.15 <sup>a</sup> $\pm$ 7.57   | 432       | 248.83 <sup>a</sup> $\pm$ 7.54   |
| 75% F <sub>2</sub>                       | 73        | 510.69 <sup>ab</sup> $\pm$ 18.34 | 72        | 233.48 <sup>ab</sup> $\pm$ 18.46 |
| <b>Borena <math>\times</math> Jersey</b> |           |                                  |           |                                  |
| 50% F <sub>1</sub>                       | 528       | 502.03 <sup>ab</sup> $\pm$ 10.51 | 526       | 218.84 <sup>ab</sup> $\pm$ 10.27 |
| 50% F <sub>2</sub>                       | 223       | 513.49 <sup>ab</sup> $\pm$ 11.52 | 221       | 232.29 <sup>ab</sup> $\pm$ 11.52 |
| 50% F <sub>3</sub>                       | 62        | 499.40 <sup>ab</sup> $\pm$ 23.79 | 61        | 215.39 <sup>ab</sup> $\pm$ 22.52 |
| 75% F <sub>1</sub>                       | 180       | 515.97 <sup>ab</sup> $\pm$ 15.36 | 176       | 231.72 <sup>ab</sup> $\pm$ 15.17 |
| 75% F <sub>2</sub>                       | 92        | 498.11 <sup>ab</sup> $\pm$ 9.42  | 92        | 213.44 <sup>ab</sup> $\pm$ 8.23  |
| <b>Calving year group</b>                |           | <b>P&lt;0.0001</b>               |           | <b>P&lt;0.0001</b>               |
| 1980-1984                                | 137       | 543.88 <sup>b</sup> $\pm$ 16.74  | 136       | 268.42 <sup>ab</sup> $\pm$ 16.61 |
| 1985-1989                                | 276       | 568.64 <sup>a</sup> $\pm$ 12.26  | 270       | 287.16 <sup>a</sup> $\pm$ 12.02  |
| 1990-1994                                | 523       | 520.28 <sup>c</sup> $\pm$ 8.05   | 520       | 240.56 <sup>c</sup> $\pm$ 8.06   |
| 1995-1999                                | 548       | 486.31 <sup>d</sup> $\pm$ 6.80   | 545       | 206.06 <sup>d</sup> $\pm$ 6.76   |
| 2000-2004                                | 955       | 491.88 <sup>d</sup> $\pm$ 4.86   | 950       | 211.35 <sup>d</sup> $\pm$ 4.82   |
| 2005-2009                                | 945       | 541.92 <sup>b</sup> $\pm$ 5.02   | 942       | 257.96 <sup>b</sup> $\pm$ 5.01   |
| 2010-2014                                | 1054      | 444.82 <sup>e</sup> $\pm$ 3.54   | 1050      | 166.94 <sup>e</sup> $\pm$ 3.55   |
| 2015-2019                                | 970       | 479.31 <sup>d</sup> $\pm$ 4.60   | 967       | 204.34 <sup>d</sup> $\pm$ 4.68   |
| <b>Calving season group</b>              |           | <b>NS</b>                        |           | <b>NS</b>                        |
| Dry                                      | 2395      | 494.88 $\pm$ 3.27                | 2381      | 215.18 $\pm$ 3.25                |
| Short rain                               | 1345      | 497.58 $\pm$ 4.16                | 1340      | 218.56 $\pm$ 4.16                |
| Long rain                                | 1668      | 497.22 $\pm$ 3.77                | 1659      | 215.85 $\pm$ 3.75                |
| <b>Parity</b>                            |           | <b>P&lt;0.0001</b>               |           | <b>P&lt;0.0001</b>               |
| 2  | 1229      | 525.62 <sup>a</sup> $\pm$ 5.07   | 1218      | 245.86 <sup>a</sup> $\pm$ 4.96   |
| 3  | 1010      | 498.11 <sup>b</sup> $\pm$ 4.96   | 1004      | 208.70 <sup>b</sup> $\pm$ 4.92   |
| 4  | 804       | 473.39 <sup>b</sup> $\pm$ 5.41   | 801       | 193.40 <sup>b</sup> $\pm$ 5.35   |
| 5  | 672       | 473.18 <sup>b</sup> $\pm$ 5.94   | 670       | 193.40 <sup>b</sup> $\pm$ 5.98   |
| 6  | 530       | 460.04 <sup>b</sup> $\pm$ 6.27   | 528       | 180.67 <sup>b</sup> $\pm$ 6.39   |
| 7  | 427       | 470.76 <sup>b</sup> $\pm$ 7.72   | 427       | 190.92 <sup>b</sup> $\pm$ 7.70   |
| 8  | 310       | 459.53 <sup>b</sup> $\pm$ 10.60  | 308       | 181.83 <sup>b</sup> $\pm$ 10.76  |
| 9  | 227       | 460.67 <sup>b</sup> $\pm$ 15.71  | 227       | 181.55 <sup>b</sup> $\pm$ 17.11  |
| 10                                       | 199       | 423.11 <sup>c</sup> $\pm$ 14.37  | 197       | 143.32 <sup>c</sup> $\pm$ 14.43  |

❖ *Superscripts<sup>a, b, c, d, e</sup> in the same fixed effect indicates differences among sample means,*

*NS = not significant.*

#### 4.1.1.5. Number of services per conception (NSC)

The least square means ( $\pm$ SE) for fixed effects of genetic groups, calving year groups and season group and parity are presented in (Table 8). In this study, the overall mean ( $\pm$ SE) for NSC of Pure Borena, Borena  $\times$  HF and Jersey genetic group was  $1.85 \pm 1.37$  in ranged between  $1.33 \pm 0.24$  and  $2.13 \pm 0.14$ .

The fixed effects of genetic group and calving year had a significant ( $P < 0.0001$ ) influence on NSC but parity and calving season had not. The lowest and highest NSC, respectively, were recorded by 50% F<sub>3</sub> and 75% F<sub>1</sub> genotype of HF  $\times$  Borena crosses whereas 75% F<sub>2</sub> and 50% F<sub>2</sub> genotype of Jersey  $\times$  Borena crosses, respectively. The 50% F<sub>3</sub> genotypes of HF  $\times$  Borena whereas the 75% F<sub>2</sub> and 50% F<sub>3</sub> of Jersey  $\times$  Borena crosses have shown a better performance for NSC trait. The least square mean ( $\pm$ SE) of NSC for pure Borena dairy herds was  $1.98 \pm 0.04$ .

Trend analysis of NSC shown that cows calved during 1990 to 1994 required lower ( $1.60 \pm 0.05$ ) values and cows calved during 1980 to 1984 required higher ( $2.02 \pm 0.13$ ) values (Figure 5).

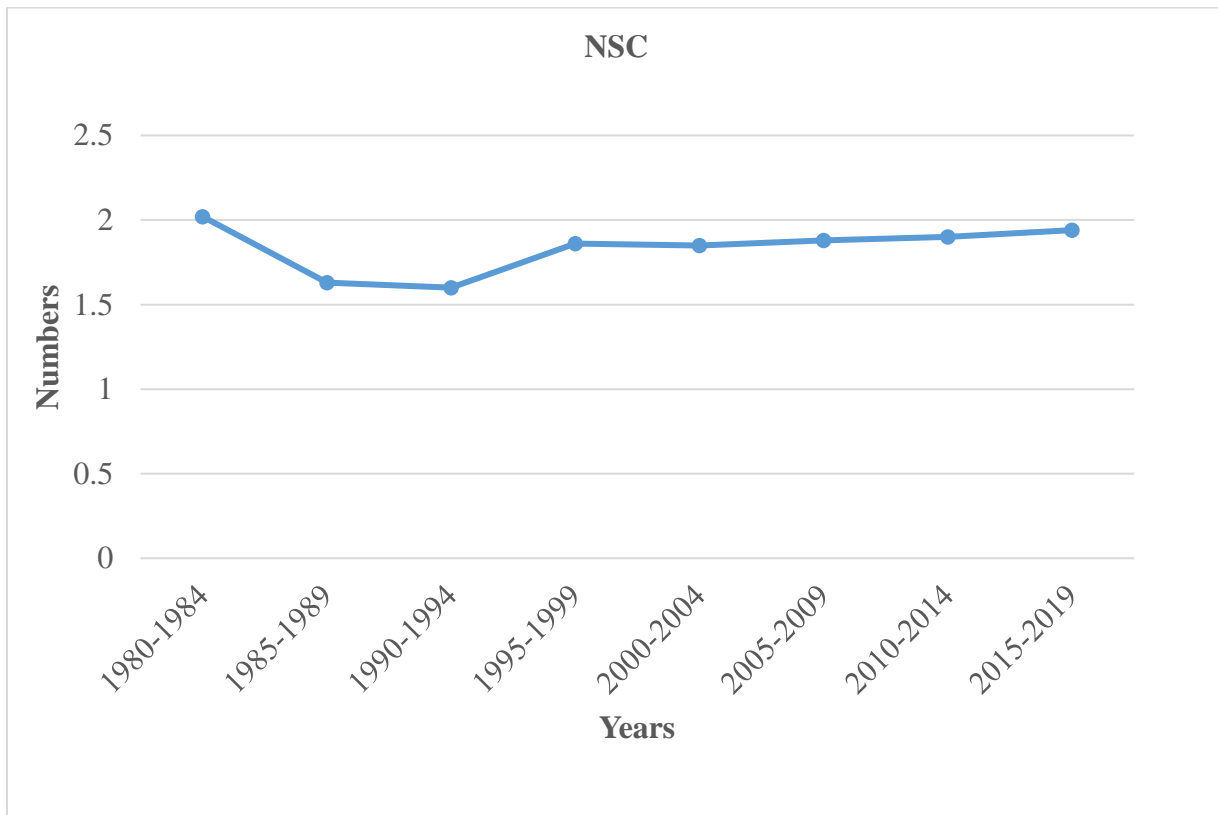


Figure 5. The trend of number of services per conception (NSC) over year of calving

Table 8. Least Square means ( $\pm$ SE) of NSC

| Fixed effects                            | NSC  |                                |
|--|------|--------------------------------|
|  | N    | LSM $\pm$ SE                   |
| Overall                                  | 5490 | 1.85 $\pm$ 1.37                |
| CV (%)                                   |      | 21.64                          |
| <b>Genetic group</b>                     |      | <b>P&lt;0.0001</b>             |
| Pure Borena                              | 1419 | 1.98 <sup>ab</sup> $\pm$ 0.04  |
| <b>Borena <math>\times</math> HF</b>     |      |                                |
| 50% F <sub>1</sub>                       | 2000 | 1.77 <sup>abc</sup> $\pm$ 0.03 |
| 50% F <sub>2</sub>                       | 272  | 1.83 <sup>abc</sup> $\pm$ 0.09 |
| 50% F <sub>3</sub>                       | 161  | 1.65 <sup>abc</sup> $\pm$ 0.09 |
| 75% F <sub>1</sub>                       | 444  | 2.14 <sup>a</sup> $\pm$ 0.08   |
| 75% F <sub>2</sub>                       | 68   | 1.77 <sup>abc</sup> $\pm$ 0.15 |
| <b>Borena <math>\times</math> Jersey</b> |      |                                |
| 50% F <sub>1</sub>                       | 629  | 1.70 <sup>abc</sup> $\pm$ 0.06 |
| 50% F <sub>2</sub>                       | 226  | 1.96 <sup>ab</sup> $\pm$ 0.11  |
| 50% F <sub>3</sub>                       | 63   | 1.35 <sup>c</sup> $\pm$ 0.10   |
| 75% F <sub>1</sub>                       | 111  | 1.43 <sup>bc</sup> $\pm$ 0.09  |
| 75% F <sub>2</sub>                       | 98   | 1.33 <sup>c</sup> $\pm$ 0.24   |
| <b>Calving year group</b>                |      | <b>P&lt;0.0014</b>             |
| 1980-1984                                | 172  | 2.02 <sup>a</sup> $\pm$ 0.13   |
| 1985-1989                                | 289  | 1.63 <sup>b</sup> $\pm$ 0.08   |
| 1990-1994                                | 533  | 1.60 <sup>b</sup> $\pm$ 0.05   |
| 1995-1999                                | 529  | 1.86 <sup>a</sup> $\pm$ 0.06   |
| 2000-2004                                | 928  | 1.85 <sup>a</sup> $\pm$ 0.05   |
| 2005-2009                                | 995  | 1.88 <sup>a</sup> $\pm$ 0.05   |
| 2010-2014                                | 1098 | 1.90 <sup>a</sup> $\pm$ 0.05   |
| 2015-2019                                | 946  | 1.94 <sup>a</sup> $\pm$ 0.05   |
| <b>Calving year season</b>               |      | <b>NS</b>                      |
| Dry                                      | 2423 | 1.87 $\pm$ 0.03                |
| Short rain                               | 1369 | 1.80 $\pm$ 0.04                |
| Long rain                                | 1698 | 1.87 $\pm$ 0.04                |
| <b>Parity</b>                            |      | <b>NS</b>                      |
| 1  | 1079 | 1.81 $\pm$ 0.04                |
| 2  | 1083 | 1.79 $\pm$ 0.04                |
| 3  | 888  | 1.87 $\pm$ 0.05                |
| 4  | 672  | 1.83 $\pm$ 0.05                |
| 5  | 540  | 1.97 $\pm$ 0.07                |
| 6  | 398  | 1.82 $\pm$ 0.06                |
| 7  | 295  | 1.82 $\pm$ 0.08                |
| 8  | 187  | 2.13 $\pm$ 0.14                |
| 9  | 193  | 1.96 $\pm$ 0.17                |
| 10                                       | 155  | 2.08 $\pm$ 0.26                |

❖ *Superscripts<sup>a, b, c</sup> in the same fixed effect indicates differences among sample means, NS = not significant.*

#### 4.1.2. Lactation performance

The lactation performance of dairy cattle is usually evaluated by determining the total milk yield per lactation, average daily milk yield, lactation persistency and lactation length.

##### 4.1.2.1. Daily milk yield (DMY)

The least square mean ( $\pm$ SE) for fixed effects genetic group, calving year group, calving season group and parity of daily milk yields values are shown in Table 9. The overall least square mean for daily milk yield of the pure Borena, Borena  $\times$  HF and Jersey genetic group was  $4.86 \pm 1.63$  liters per day per cow.

The daily milk trait was significantly ( $P < 0.0001$ ) affected by fixed effects of genetic group, calving year, season of calving and parity. For both Borena  $\times$  HF and Jersey crosses, the 50%  $F_1$  had obtained higher daily milk yield when compared to other genetic groups. Daily milk yield was decreased from 1<sup>st</sup> generation to  $F_2$  and  $F_3$  in both 50% and 75% crossbred cows. The least square mean for pure Borena dairy cows was  $2.13 \pm 0.03$  liters per day per cow.

The least square mean analysis of daily milk yield had significantly ( $P < 0.0001$ ) higher ( $5.82 \pm 0.16$  liters) and lower ( $4.08 \pm 0.13$  liters), respectively, recorded during the year 2012 to 2015 and 2004 to 2007. The seasonal change of weather condition showed significant ( $P < 0.05$ ) difference on daily milk yield traits among seasons. The better daily milk yield was observed in cows calved during dry and main rain season than short rain season.

The daily milk yield trait had a highly significant ( $P < 0.0001$ ) effect among parity of cows. The higher and lower daily milk yield, respectively, was observed in parity ten and parity one. Statistically, there was no significant ( $P < 0.0001$ ) difference observed between Parity 2<sup>nd</sup>, 5<sup>th</sup>, 6<sup>th</sup>, and 7<sup>th</sup> and between parity 3<sup>rd</sup> and 4<sup>th</sup> of cows.

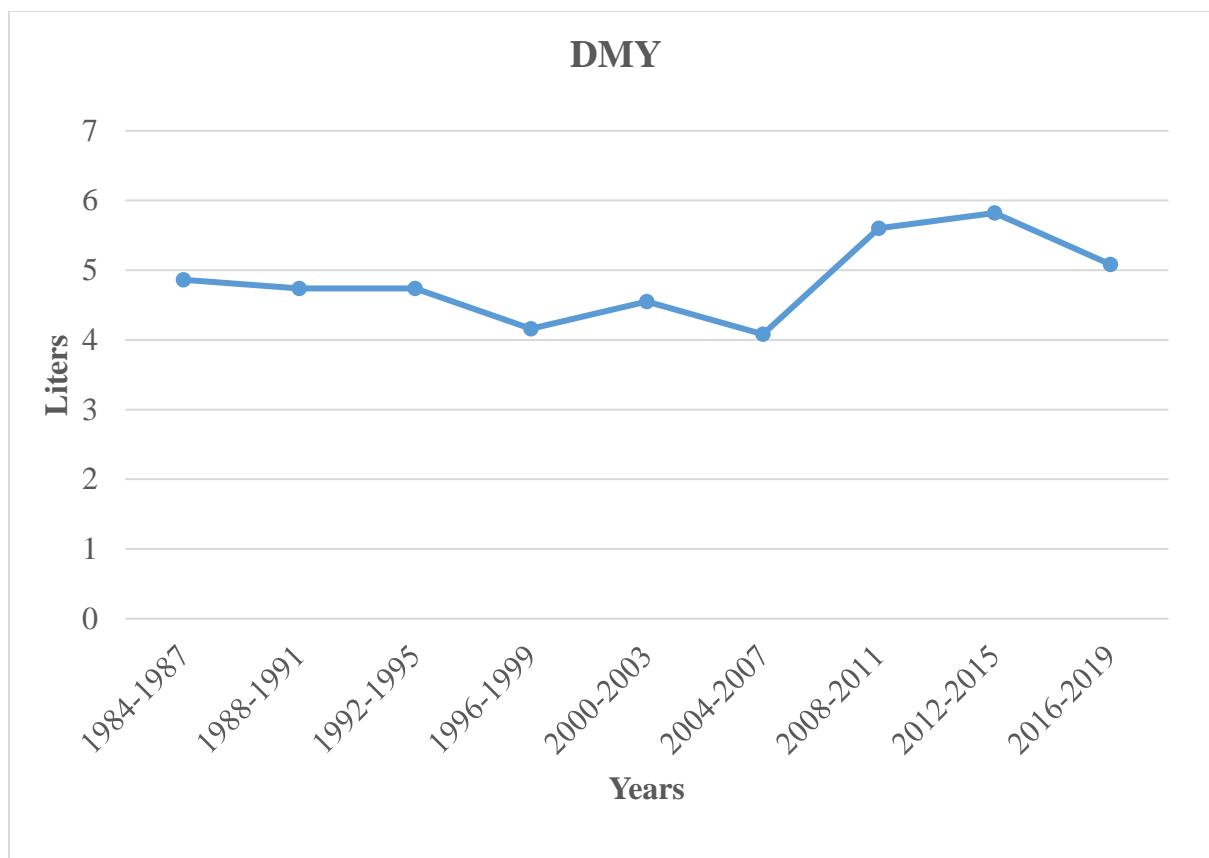


Figure 6. The trend of daily milk yield (DMY) over year of calving.

#### 4.1.2.2. Lactation length (LL)

In this study, the least square mean ( $\pm$ SE) of lactation length for Borena  $\times$  HF and Jersey and pure Borena genetic groups are shown in (Table 9). The overall least mean ( $\pm$ SE) for LL of eleven genetic group was  $287.77 \pm 92.81$  days.

The fixed effect of genetic groups, year of calving, season of calving and parities had a highly significant ( $P < 0.0001$ ) effect on lactation length. The 75%  $F_1$  crosses of HF  $\times$  Borena was longest ( $358.91 \pm 13.43$  days) lactation length and the shortest lactation length was recorded with 50%  $F_1$  ( $318.45 \pm 2.63$  days) generation. For Jersey  $\times$  Borena crosses, the longest ( $361.21 \pm 6.86$  days) and shortest ( $264.35 \pm 11.03$ ) lactation length, respectively, was observed with 50%  $F_1$  and 50%  $F_3$ . The least square mean of lactation length for pure Borena was  $219.17 \pm 2.77$  days.

The longest ( $360.28 \pm 10.45$  days) and shortest ( $194.79 \pm 7.70$  days) lactation length, respectively, was recorded in animals calved between 1984 to 1987 and 2016 to 2019.

The better lactation length was observed in cows calved during dry than main rain and short rain season. The parity of cows has been significantly ( $P < 0.0001$ ) effect on lactation length. The longest ( $313.04 \pm 4.18$  days) lactation length was observed in first parity and the lowest ( $252.17 \pm 8.25$  days) lactation length was recorded on 7<sup>th</sup> parity. There was no significant ( $P < 0.0001$ ) difference observed between the parity 3<sup>rd</sup>, 4<sup>th</sup>, 5<sup>th</sup> and 6<sup>th</sup>.

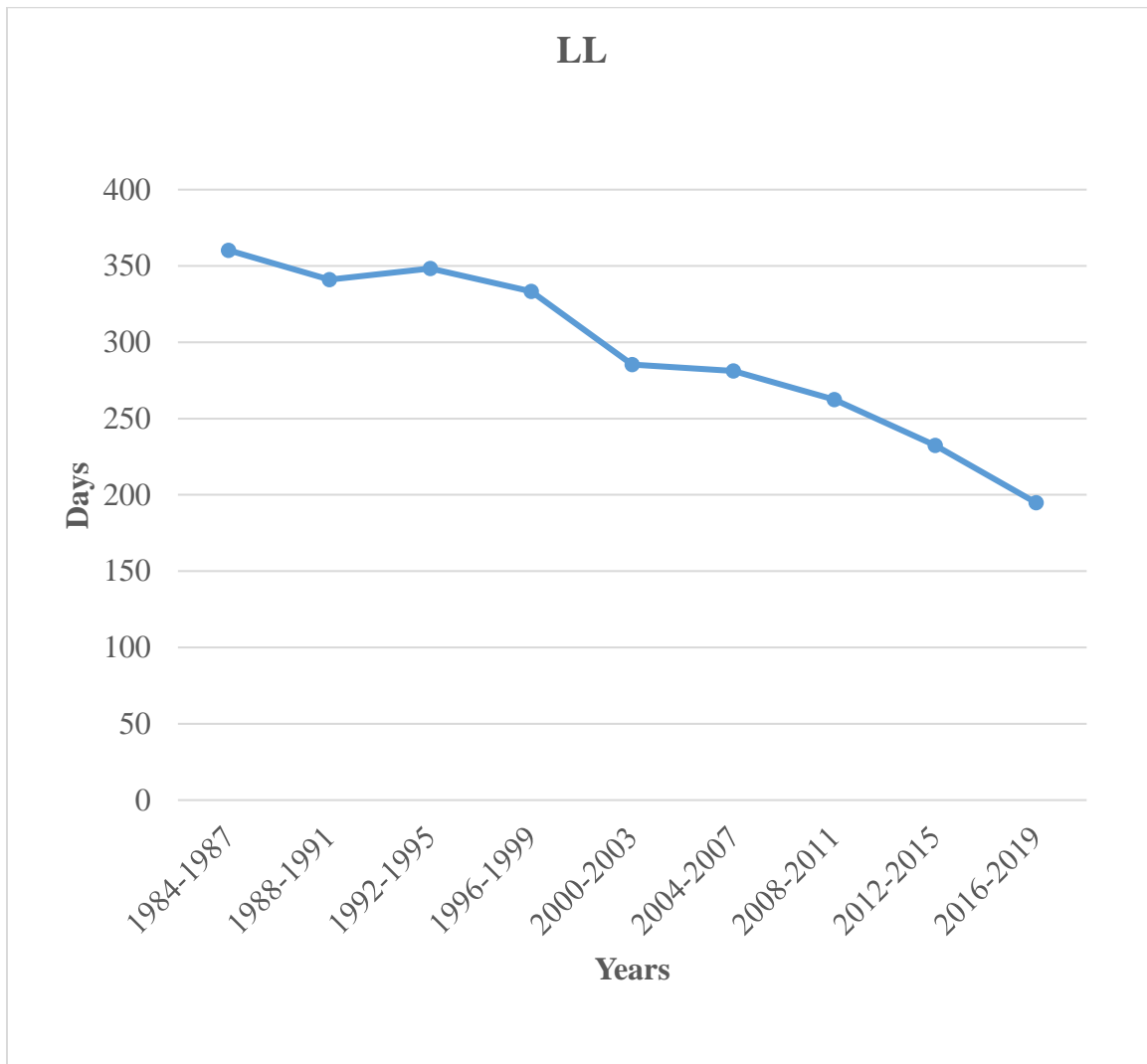


Figure 7. The trend of lactation length (LL) over year of calving.

Table 9. Least square means ( $\pm$ SE) of daily milk yield and lactation length.

| Fixed effects                            | DMY (Liters) |                               | LL (days)                        |              |
|--|--------------|-------------------------------|----------------------------------|--------------|
|  | N            | LSM $\pm$ SE                  | LSM $\pm$ SE                     | LSM $\pm$ SE |
| <b>Overall</b>                           | 3888         | 4.86 $\pm$ 1.63               | 287.77 $\pm$ 92.81               |              |
| <b>CV (%)</b>                            |              | 23.68                         | 22.78                            |              |
| <b>Genetic group</b>                     |              | <b>P&lt;0.0001</b>            | <b>P&lt;0.0001</b>               |              |
| Pure Borena                              | 1371         | 2.13 <sup>d</sup> $\pm$ 0.03  | 219.17 <sup>c</sup> $\pm$ 2.77   |              |
| <b>Borena <math>\times</math> HF</b>     |              |                               |                                  |              |
| 50% F <sub>1</sub>                       | 1212         | 7.47 <sup>a</sup> $\pm$ 0.07  | 318.45 <sup>a</sup> $\pm$ 2.63   |              |
| 50% F <sub>2</sub>                       | 205          | 5.01 <sup>c</sup> $\pm$ 0.11  | 343.72 <sup>a</sup> $\pm$ 8.74   |              |
| 50% F <sub>3</sub>                       | 128          | 4.95 <sup>c</sup> $\pm$ 0.13  | 322.07 <sup>a</sup> $\pm$ 9.09   |              |
| 75% F <sub>1</sub>                       | 181          | 6.99 <sup>a</sup> $\pm$ 0.24  | 358.91 <sup>a</sup> $\pm$ 13.43  |              |
| 75% F <sub>2</sub>                       | 50           | 5.04 <sup>c</sup> $\pm$ 0.44  | 350.75 <sup>a</sup> $\pm$ 19.43  |              |
| <b>Borena <math>\times</math> Jersey</b> |              |                               |                                  |              |
| 50% F <sub>1</sub>                       | 414          | 5.76 <sup>b</sup> $\pm$ 0.12  | 361.21 <sup>a</sup> $\pm$ 6.86   |              |
| 50% F <sub>2</sub>                       | 160          | 4.35 <sup>c</sup> $\pm$ 0.11  | 335.52 <sup>a</sup> $\pm$ 7.71   |              |
| 50% F <sub>3</sub>                       | 46           | 4.51 <sup>c</sup> $\pm$ 0.24  | 264.35 <sup>b</sup> $\pm$ 11.03  |              |
| 75% F <sub>1</sub>                       | 83           | 4.81 <sup>c</sup> $\pm$ 0.22  | 339.41 <sup>a</sup> $\pm$ 12.41  |              |
| 75% F <sub>2</sub>                       | 38           | 4.99 <sup>c</sup> $\pm$ 0.81  | 357.33 <sup>a</sup> $\pm$ 22.66  |              |
| <b>Calving year group</b>                |              | <b>P&lt;0.0001</b>            | <b>P&lt;0.0001</b>               |              |
| 1984-1987                                | 185          | 4.86 <sup>bc</sup> $\pm$ 0.18 | 360.28 <sup>a</sup> $\pm$ 10.45  |              |
| 1988-1991                                | 280          | 4.74 <sup>cd</sup> $\pm$ 0.12 | 340.99 <sup>b</sup> $\pm$ 7.84   |              |
| 1992-1995                                | 345          | 4.74 <sup>cd</sup> $\pm$ 0.11 | 348.32 <sup>ab</sup> $\pm$ 7.52  |              |
| 1996-1999                                | 428          | 4.16 <sup>e</sup> $\pm$ 0.12  | 333.38 <sup>b</sup> $\pm$ 6.37   |              |
| 2000-2003                                | 699          | 4.55 <sup>d</sup> $\pm$ 0.11  | 285.32 <sup>c</sup> $\pm$ 3.74   |              |
| 2004-2007                                | 584          | 4.08 <sup>e</sup> $\pm$ 0.13  | 281.20 <sup>c</sup> $\pm$ 4.74   |              |
| 2008-2011                                | 713          | 5.60 <sup>a</sup> $\pm$ 0.13  | 262.52 <sup>d</sup> $\pm$ 3.66   |              |
| 2012-2015                                | 486          | 5.82 <sup>a</sup> $\pm$ 0.16  | 232.41 <sup>e</sup> $\pm$ 3.89   |              |
| 2016-2019                                | 168          | 5.08 <sup>b</sup> $\pm$ 0.30  | 194.79 <sup>f</sup> $\pm$ 7.70   |              |
| <b>Calving year season</b>               |              | <b>P (0.005)</b>              | <b>P (0.027)</b>                 |              |
| Dry                                      | 1778         | 4.99 <sup>a</sup> $\pm$ 0.07  | 297.30 <sup>a</sup> $\pm$ 2.78   |              |
| Short rain                               | 1127         | 4.40 <sup>b</sup> $\pm$ 0.10  | 278.56 <sup>b</sup> $\pm$ 3.58   |              |
| Long rain                                | 983          | 5.13 <sup>a</sup> $\pm$ 0.09  | 279.91 <sup>b</sup> $\pm$ 3.59   |              |
| <b>Parity</b>                            |              | <b>P&lt;0.0001</b>            | <b>P &lt;0.0001</b>              |              |
| 1  | 681          | 4.17 <sup>e</sup> $\pm$ 0.09  | 313.04 <sup>a</sup> $\pm$ 4.18   |              |
| 2  | 678          | 4.76 <sup>d</sup> $\pm$ 0.10  | 302.90 <sup>ab</sup> $\pm$ 4.28  |              |
| 3  | 589          | 5.10 <sup>cd</sup> $\pm$ 0.12 | 280.88 <sup>c</sup> $\pm$ 4.36   |              |
| 4  | 484          | 5.12 <sup>cd</sup> $\pm$ 0.14 | 285.61 <sup>b</sup> $\pm$ 5.34   |              |
| 5  | 412          | 4.94 <sup>d</sup> $\pm$ 0.16  | 275.97 <sup>c</sup> $\pm$ 5.74   |              |
| 6  | 334          | 4.91 <sup>d</sup> $\pm$ 0.19  | 276.04 <sup>c</sup> $\pm$ 7.29   |              |
| 7  | 254          | 4.93 <sup>d</sup> $\pm$ 0.23  | 252.17 <sup>d</sup> $\pm$ 8.25   |              |
| 8  | 174          | 5.36 <sup>c</sup> $\pm$ 0.33  | 266.27 <sup>cd</sup> $\pm$ 10.80 |              |
| 9  | 146          | 5.65 <sup>b</sup> $\pm$ 0.47  | 252.22 <sup>d</sup> $\pm$ 14.12  |              |
| 10                                       | 136          | 6.50 <sup>a</sup> $\pm$ 0.45  | 270.68 <sup>cd</sup> $\pm$ 16.98 |              |

Superscripts <sup>a, b, c, d, e, f</sup> in the same fixed effect indicates differences among sample means.

#### 4.1.2.3. Lactation milk yield (LMY)

Results of the least square mean ( $\pm$ SE) for fixed effects of genetic group, calving year period, calving season and parity are indicated in (Table 10). The overall least square ( $\pm$ SE) for LMY of eleven genetic group in this study was  $1488.23 \pm 70.14$  liters.

The fixed effects of genetic group had highly significant ( $P < 0.0001$ ) influence on the lactation milk yield. For HF  $\times$  Borena crosses, the 75% F<sub>1</sub> had produced higher (2461.92 liters) while for Jersey  $\times$  Borena crosses, the 50% F<sub>1</sub> had recorded the higher (2037.62 liters) milk yield per lactation than other blood level groups. For HF  $\times$  Borena the 50% F<sub>1</sub> has produced 111 liters less milk than 75% F<sub>1</sub> cows whereas for Jersey  $\times$  Borena, the 50% F<sub>1</sub> has produced 437 liters more milk than 75% F<sub>1</sub> cows. Milk yield per lactation was decreased from 50% F<sub>1</sub> to F<sub>3</sub> and from 75% F<sub>1</sub> to F<sub>2</sub>. The least square mean for lactation milk yield of pure Borena cows was  $463.61 \pm 8.46$  liters.

The year of calving had significantly ( $P < 0.0001$ ) influence on lactation milk yield. The highest (1737.64 liters) lactation milk yield was observed during 1984 to 1987 while the lowest (1131.58 liters) lactation milk yield was recorded 2016 to 2019. The most favorable years for animals to perform better lactation yield were the four-year groups (1984 to 1987, 1988 to 1991, 1992 to 1995, 2008 to 2011).

The least square analysis revealed that lactation milk yield was significantly ( $P < 0.05$ ) affected by season of calving. The higher lactation milk yield was recorded in dry season and main rainy season.

The lactation milk yield trait differed significantly ( $P < 0.0001$ ) among parities of cows. The trend analysis indicated that the highest (1831.08 liters/lactation) and lowest (1359.64 liters/lactation) lactation milk yield, respectively, was recorded in the parity ten and parity seven.

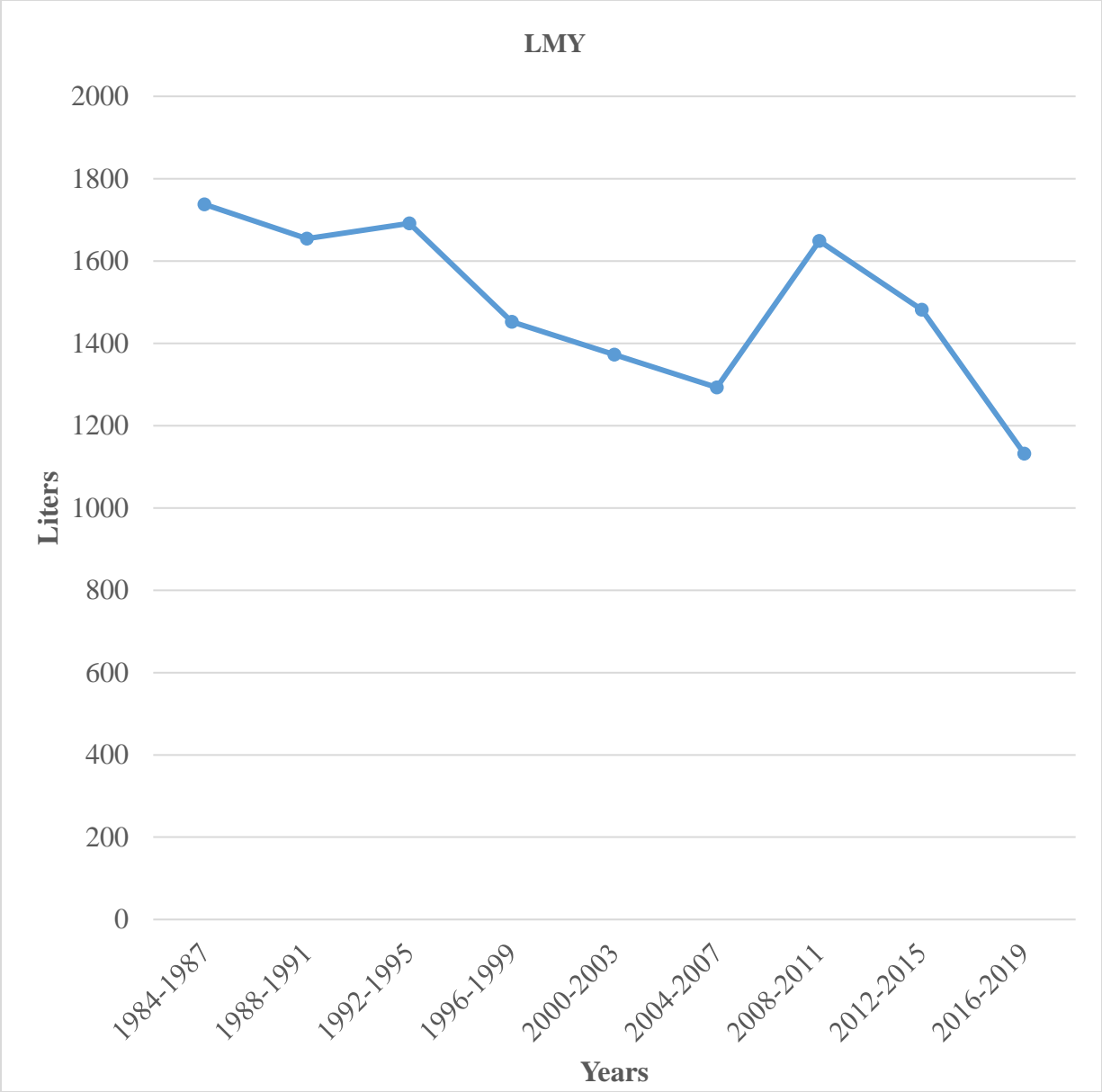


Figure 8. The trend of lactation milk yield over year of calving.

Table 10. Least Square means ( $\pm$ SE) of lactation milk yield

| Fixed effects                            | LMY  |                                    |
|--|------|------------------------------------|
|  | N    | LSM $\pm$ SE                       |
| Overall                                  | 4300 | 1488.23 $\pm$ 70.14                |
| CV                                       |      | 27.60                              |
| <b>Genetic group</b>                     |      | <b>P&lt;0.0001</b>                 |
| Pure Borena                              | 1462 | 463.61 <sup>c</sup> $\pm$ 8.46     |
| <b>Borena <math>\times</math> HF</b>     |      |                                    |
| 50% F <sub>1</sub>                       | 1394 | 2350.96 <sup>a</sup> $\pm$ 27.60   |
| 50% F <sub>2</sub>                       | 261  | 1693.61 <sup>c</sup> $\pm$ 50.72   |
| 50% F <sub>3</sub>                       | 159  | 1618.20 <sup>c</sup> $\pm$ 67.12   |
| 75% F <sub>1</sub>                       | 180  | 2461.92 <sup>a</sup> $\pm$ 109.82  |
| 75% F <sub>2</sub>                       | 69   | 1763.25 <sup>bc</sup> $\pm$ 178.82 |
| <b>Borena <math>\times</math> Jersey</b> |      |                                    |
| 50% F <sub>1</sub>                       | 426  | 2037.62 <sup>b</sup> $\pm$ 53.07   |
| 50% F <sub>2</sub>                       | 147  | 1476.48 <sup>c</sup> $\pm$ 53.08   |
| 50% F <sub>3</sub>                       | 59   | 1181.13 <sup>d</sup> $\pm$ 69.99   |
| 75% F <sub>1</sub>                       | 99   | 1600.18 <sup>c</sup> $\pm$ 83.32   |
| 75% F <sub>2</sub>                       | 44   | 1786.87 <sup>b</sup> $\pm$ 303.60  |
| <b>Calving year group</b>                |      | <b>P&lt;0.0001</b>                 |
| 1984-1987                                | 230  | 1737.64 <sup>a</sup> $\pm$ 76.19   |
| 1988-1991                                | 325  | 1654.69 <sup>a</sup> $\pm$ 56.19   |
| 1992-1995                                | 390  | 1691.48 <sup>a</sup> $\pm$ 51.69   |
| 1996-1999                                | 473  | 1452.00 <sup>b</sup> $\pm$ 51.92   |
| 2000-2003                                | 744  | 1372.57 <sup>bc</sup> $\pm$ 39.60  |
| 2004-2007                                | 629  | 1292.97 <sup>c</sup> $\pm$ 52.38   |
| 2008-2011                                | 758  | 1648.98 <sup>a</sup> $\pm$ 49.31   |
| 2012-2015                                | 531  | 1481.81 <sup>b</sup> $\pm$ 55.06   |
| 2016-2019                                | 220  | 1131.58 <sup>d</sup> $\pm$ 95.70   |
| <b>Calving year season</b>               |      | <b>P (0.0280)</b>                  |
| Dry                                      | 1915 | 1555.60 <sup>a</sup> $\pm$ 26.75   |
| Short rain                               | 1264 | 1329.19 <sup>b</sup> $\pm$ 35.02   |
| Long rain                                | 1121 | 1542.94 <sup>a</sup> $\pm$ 39.64   |
| <b>Parity</b>                            |      | <b>P&lt;0.0001</b>                 |
| 1  | 722  | 1379.28 <sup>c</sup> $\pm$ 76.19   |
| 2  | 719  | 1527.20 <sup>bc</sup> $\pm$ 40.68  |
| 3  | 630  | 1527.72 <sup>bc</sup> $\pm$ 46.36  |
| 4  | 525  | 1571.34 <sup>bc</sup> $\pm$ 55.26  |
| 5  | 453  | 1484.07 <sup>b</sup> $\pm$ 61.07   |
| 6  | 375  | 1450.02 <sup>bc</sup> $\pm$ 68.25  |
| 7  | 295  | 1359.64 <sup>c</sup> $\pm$ 79.67   |
| 8  | 215  | 1506.02 <sup>bc</sup> $\pm$ 109.43 |
| 9  | 187  | 1592.40 <sup>b</sup> $\pm$ 166.19  |
| 10                                       | 179  | 1831.08 <sup>a</sup> $\pm$ 171.45  |

❖ *Superscripts<sup>a, b, c, d, e</sup> in the same fixed effect indicates differences among sample means*

## 4.2. On Farm Study

### 4.2.1. Household characteristics

The results relating to educational level of the respondents and the gender of household head are summarized in (Table 11). The educational level of the respondents ranged from totally illiterate to those with higher education. Overall, 36.7% of the respondents were totally illiterate and 63.3 % had attended different levels of formal education. Out of the interviewed respondents 53.3 % in Adea Berga were totally illiterate, 28.3 % in Ambo had attended primary school and can read and write, 11.7 % in Walmera had attended secondary school and 6.7 % in Ambo had attended the higher education. The proportion of respondents attended formal education were higher in Ambo than other two districts (Table 11).

On average, the 87.8% of the total respondents were male headed households and the rest 12.2% were female headed households. Ambo has a higher proportion of female-headed families than the other two districts.

Table 11. Gender of the HH head (%) and educational level of respondents (%).

| Parameters               | Study areas |            |            |            |           |            |            |            |
|--------------------------|-------------|------------|------------|------------|-----------|------------|------------|------------|
|                          | Walmera     |            | Adea Berga |            | Ambo      |            | Total      |            |
| <b>Education's level</b> | N           | %          | N          | %          | N         | %          | N          | %          |
| Illiterate               | 22          | 36.7       | 32         | 53.3       | 12        | 20         | 66         | 36.7       |
| Read and write           | 15          | 25         | 16         | 26.7       | 17        | 28.3       | 48         | 26.7       |
| Primary School           | 16          | 26.7       | 9          | 15         | 17        | 28.3       | 42         | 23.3       |
| Secondary school         | 7           | 11.6       | 3          | 5          | 7         | 11.7       | 17         | 9.4        |
| Higher Education         | 0           | 0          | 0          | 0          | 4         | 6.7        | 4          | 2.2        |
| Diploma                  | 0           | 0          | 0          | 0          | 3         | 5          | 3          | 1.7        |
| <b>Total</b>             | <b>60</b>   | <b>100</b> | <b>60</b>  | <b>100</b> | <b>60</b> | <b>100</b> | <b>180</b> | <b>100</b> |
| <b>Gender of HH head</b> |             |            |            |            |           |            |            |            |
| Male                     | 52          | 86.7       | 56         | 93.3       | 50        | 83.3       | 158        | 87.8       |
| Female                   | 8           | 13.3       | 4          | 6.7        | 10        | 16.7       | 22         | 12.2       |
| <b>Total</b>             | <b>60</b>   | <b>100</b> | <b>60</b>  | <b>100</b> | <b>60</b> | <b>100</b> | <b>180</b> | <b>100</b> |

*N= Number of respondents*

The average family size of the study areas was  $6.84 \pm 2.17$ . According to the survey result the family sizes of the three districts were  $7.1 \pm 2.7$ ,  $6.7 \pm 2.2$ , and  $6.7 \pm 1.6$ , respectively, in Adea Berga, Ambo and Walmera. The overall average age of the respondents was 45 years and ranged

from 20 to 79 years. The details result of family size and age of the respondents were shown in table 12 as follows.

Table 12. Family size mean ( $\pm$ SD) and age of respondents mean ( $\pm$ SD).

| Study areas | Parameters             |                    |                      | Overall mean  |
|-------------|------------------------|--------------------|----------------------|---------------|
|             | Age of the respondents | Male (Family size) | Female (Family size) |               |
| Walmera     | 44.7 $\pm$ 10.1        | 3.4 $\pm$ 1.1      | 3.3 $\pm$ 1.3        | 6.7 $\pm$ 1.6 |
| Ade'a Berga | 46.5 $\pm$ 10.5        | 3.7 $\pm$ 1.5      | 3.4 $\pm$ 1.6        | 7.1 $\pm$ 2.7 |
| Ambo        | 45.4 $\pm$ 11.2        | 3.2 $\pm$ 1.6      | 3.4 $\pm$ 1.3        | 6.7 $\pm$ 2.2 |
| Total       | 45.5 $\pm$ 10.6        | 3.4 $\pm$ 1.4      | 3.4 $\pm$ 1.4        | 6.8 $\pm$ 2.2 |

*SD = Standard deviation*

Overall, 75% and 12.2%, respectively, of the respondents were farmers and dairy producers while the rest were mentioned others types of job as their main occupations. The 13.3% from Walmera, 15% from Ambo and 8.3% from Adea Berga of dairy farm owners stated that dairy production was their main occupation.

Table 13. Occupational status of the respondents in study areas (%)

| Parameters<br><b>Major Occupation</b> | Study areas |      |             |      |      |      |       |      |
|---------------------------------------|-------------|------|-------------|------|------|------|-------|------|
|                                       | Walmera     |      | Ade'a Berga |      | Ambo |      | Total |      |
|                                       | N           | %    | N           | %    | N    | %    | N     | %    |
| Farmers                               | 51          | 85   | 47          | 78.3 | 37   | 61.7 | 135   | 75   |
| Business man                          | 0           | 0    | 3           | 5    | 2    | 3.3  | 5     | 2.8  |
| Employed                              | 1           | 1.7  | 1           | 1.7  | 6    | 10   | 8     | 4.4  |
| Retired                               | 0           | 0    | 1           | 1.7  | 2    | 3.3  | 3     | 1.7  |
| Farmers and business man              | 0           | 0    | 1           | 1.7  | 1    | 1.7  | 2     | 1.1  |
| Pensions                              | 0           | 0    | 2           | 3.3  | 3    | 5    | 5     | 2.8  |
| Dairy producers                       | 8           | 13.3 | 5           | 8.3  | 9    | 15   | 22    | 12.2 |
| Total                                 | 60          | 100  | 60          | 100  | 60   | 100  | 180   | 100  |

*N= Number of respondents*

#### 4.2.2. Dairy herds management practices in the study areas

##### 4.2.2.1. Feeding system and feed supplement

Generally, 51.7% and 45% of the respondents, respectively, said that combination feeding system and stall feeding as the primary feeding management practices while the remaining mentioned grazing and cut and carry system as the main feeding system. In Adea Berga and Walmera 56.7% and 53.3% of the respondents, respectively, stated that combination feeding system was the main

feeding system. Furthermore, stall feeding were the main feeding systems in Ambo (55%) areas (Table 14).

The respondents in Adea Berga (98.3%), Walmera (96.7%) and Ambo (100%) stated that they supplement their dairy cattle. Animals in most of farm groups were fed natural pasture (grazing), grass hay, straw (crop residues), milling byproducts (wheat bran and wheat middling), dairy concentrate mix (compounded or mitin), atela, some green feeds like alfalfa, elephant grass, oats-vetch and beverage by products.

Table 14. Dairy cows feeding system and feed supplements in the study areas.

| Parameters                                  | Study areas |      |             |      |      |     |       |      |
|---|-------------|------|-------------|------|------|-----|-------|------|
|   | Walmera     |      | Ade'a Berga |      | Ambo |     | Total |      |
|   | N           | %    | N           | %    | N    | %   | N     | %    |
| <b>Types feeding system of dairy cattle</b> |             |      |             |      |      |     |       |      |
| Grazing                                     | 3           | 5    | 2           | 3.3  | 0    | 0   | 5     | 2.7  |
| Stall feeding                               | 24          | 40   | 24          | 40   | 33   | 55  | 81    | 45   |
| Combination Feeding                         | 32          | 53.3 | 34          | 56.7 | 27   | 45  | 93    | 51.6 |
| Cut and carry and stall feeding             | 1           | 1.7  | 0           | 0    | 0    | 0   | 1     | 0.6  |
| Total                                       | 60          | 100  | 60          | 100  | 60   | 100 | 180   | 100  |
| <b>Do you supplement dairy cattle?</b>      |             |      |             |      |      |     |       |      |
| Yes   | 59          | 98.3 | 58          | 96.7 | 60   | 100 | 177   | 98.3 |
| No  | 1           | 1.7  | 2           | 3.3  | 0    | 0   | 3     | 1.7  |
| Total                                       | 60          | 100  | 60          | 100  | 60   | 100 | 180   | 100  |

*N= number of respondents*

#### 4.2.2.2. Housing and record keeping practices

A 92.2% of dairy producers in the study areas were used separate house for their dairy cattle. The dairy producers in Adea Berga and Walmera (81.7%) whereas in Ambo (71.7%) were not practicing recording system. The 78.3% of dairy producers in the study areas were stated as they are not practiced record keeping system in their farms (Table 15).

Table 15. Housing and Recording keeping practices in study areas.

| Responses                                   | Study areas |      |             |      |      |      |       |      |
|---|-------------|------|-------------|------|------|------|-------|------|
|   | Walmera     |      | Ade'a Berga |      | Ambo |      | Total |      |
|   | N           | %    | N           | %    | N    | %    | N     | %    |
| <b>Separate housing system in your farm</b> |             |      |             |      |      |      |       |      |
| Yes   | 55          | 91.7 | 58          | 96.7 | 53   | 88.3 | 166   | 92.2 |
| No  | 5           | 8.3  | 2           | 3.3  | 7    | 11.7 | 14    | 7.8  |
| Total                                       | 60          | 100  | 60          | 100  | 60   | 100  | 180   | 100  |
| <b>Recording system in your farm</b>        |             |      |             |      |      |      |       |      |
| Yes   | 11          | 18.3 | 11          | 18.3 | 17   | 28.3 | 39    | 21.7 |
| No  | 49          | 81.7 | 49          | 81.7 | 43   | 71.7 | 141   | 78.3 |
| Total                                       | 60          | 100  | 60          | 100  | 60   | 100  | 180   | 100  |

*N = Number of respondents*

#### 4.2.2.3. Frequency of watering dairy cattle

Out of 180 dairy farm producers 39.4 % and 35.6 %, respectively, said that they provided water three times and two times per day for their dairy cattle. Furthermore, 11.7 % and 12.8 %, respectively, were provided water freely and once a day for their dairy cattle (Table 16).

Table 16. Frequency of water provision for dairy cattle in the study areas.

| Parameters                   | Study areas |      |             |      |      |      |       |      |
|------------------------------|-------------|------|-------------|------|------|------|-------|------|
|                              | Walmera     |      | Ade'a Berga |      | Ambo |      | Total |      |
|                              | N           | %    | N           | %    | N    | %    | N     | %    |
| <b>Frequency of watering</b> |             |      |             |      |      |      |       |      |
| Once a day                   | 7           | 11.7 | 2           | 3.3  | 14   | 23.3 | 23    | 12.8 |
| twice a day                  | 19          | 31.7 | 20          | 33.3 | 25   | 41.7 | 64    | 35.6 |
| three times a day            | 26          | 43.3 | 28          | 46.7 | 17   | 28.3 | 71    | 39.4 |
| roam freely                  | 8           | 13.3 | 10          | 16.7 | 4    | 6.7  | 22    | 12.2 |
| Total                        | 60          | 100  | 60          | 100  | 60   | 100  | 60    | 100  |

*N = Number of respondents*

#### 4.2.3. Breeding practices in the study areas

##### 4.2.3.1. Experience and purpose of keeping dairy cattle

Out of the 180 dairy farm owners in present study 38.3% and 37.8%, respectively, were stated that they had 1 to 5 and 6 to 10 years' experience in dairy keeping. In Ambo 56.7% of the respondent have dairy cattle rearing experiences of 1 to 5 years and 41.7% of respondents in Adea Berga have dairy cattle rearing experiences 6 to 10 years. In Walmera and Adea Berga, of current study areas, 40% the dairy farm owners have greater than 10 years of experiences in crossbred dairy cattle production. The 86.1% of respondents in the study areas stated that the primary purpose of keeping

dairy cattle was for home consumption and income generation whereas 8.3% reported for home consumption only.

Table 17. Experience and purpose of keeping crossbred dairy cattle

| Parameters  | Study areas |      |             |      |      |      |       |      |
|---|-------------|------|-------------|------|------|------|-------|------|
|   | Walmera     |      | Ade'a Berga |      | Ambo |      | Total |      |
|   | N           | %    | N           | %    | N    | %    | N     | %    |
| <b>Experience in keeping crossbred dairy cows</b> |             |      |             |      |      |      |       |      |
| 1-5 years   | 10          | 16.7 | 25          | 41.7 | 34   | 56.7 | 69    | 38.3 |
| 6- 10 years                                       | 26          | 43.3 | 24          | 40   | 18   | 30.0 | 68    | 37.8 |
| greater 10 years                                  | 24          | 40   | 11          | 18.3 | 8    | 13.3 | 43    | 23.9 |
| Total   | 60          | 100  | 60          | 100  | 60   | 100  | 180   | 100  |
| <b>Purposes of keeping crossbred dairy cattle</b> |             |      |             |      |      |      |       |      |
| For home consumption                              | 3           | 5    | 4           | 6.7  | 8    | 13.3 | 15    | 8.3  |
| For consumption and income                        | 51          | 85   | 53          | 88.3 | 51   | 85   | 155   | 86.1 |
| For consumption, income and bull traction         | 6           | 10   | 3           | 5    | 1    | 1.7  | 10    | 5.6  |
| Total   | 60          | 100  | 60          | 100  | 60   | 100  | 180   | 100  |

*N= Number of respondents*

#### 4.2.3.2. Mating system

The survey result showed that farmers in the study areas use a diversified mating type (Table 18). The survey result revealed that 58.9% of dairy producers were commonly practiced both AI and natural mating followed by AI only (35.6 %). The survey also indicated that 46.7% of the respondents in Ambo practiced only AI whereas 70% and 60% of respondents in Walmera and Adea Berga, respectively, were practiced both natural mating and AI.

Table 18. Types of mating system in the study areas.

| Parameters                 | Study areas |      |             |      |      |      |       |      |
|----------------------------|-------------|------|-------------|------|------|------|-------|------|
|                            | Walmera     |      | Ade'a Berga |      | Ambo |      | Total |      |
| <b>Types of mating</b>     | N           | %    | N           | %    | N    | %    | N     | %    |
| Natural mating only        | 1           | 1.7  | 5           | 8.3  | 4    | 6.6  | 10    | 5.6  |
| AI only                    | 17          | 28.3 | 19          | 31.7 | 28   | 46.7 | 64    | 35.6 |
| Both AI and Natural mating | 42          | 70   | 36          | 60   | 28   | 46.7 | 106   | 58.9 |
| Total                      | 60          | 100  | 60          | 100  | 60   | 100  | 180   | 100  |

*N = Number of respondents*

#### 4.2.4. Fertility traits

The survey finding on prediction of fertility traits mainly age at first service, age at first calving, number of services per conception, calving interval and days open are presented in (Table 19).

##### 4.2.4.1. Age at first service (AFS)

The survey result shown that the predicted overall mean ( $\pm$ SD) of AFS in the current study areas was  $50.6 \pm 11.6$  and  $20.9 \pm 5.6$  months, respectively, for both local and crossbred dairy heifers. For indigenous dairy heifers, the shortest mean ( $\pm$ SD) ( $47.9 \pm 9.8$  months) of AFS was from Adea Berga and the longest ( $53.1 \pm 13.8$  months) was from Ambo whereas for crossbred dairy heifers, the shortest ( $19.9 \pm 5.8$  months) AFS was from Ambo whereas the longest ( $22.2 \pm 6.1$  months) AFS was from Adea Berga.

##### 4.2.4.2. Age at first calving (AFC)

The estimated overall mean ( $\pm$ SD) of AFC declared by survey result in this study for indigenous and Cross breed dairy heifers, respectively, were  $59.9 \pm 11.2$  and  $29.9 \pm 5.6$  months. The shortest ( $56.9 \pm 9.8$  months) and ( $28.9 \pm 5.8$  months) AFC were from Adea Berga and Ambo, respectively, for local and crossbred heifers. The longest ( $62.90 \pm 12.619$  and  $31.2 \pm 6.1$  months) AFC for both indigenous and cross breed dairy heifers, respectively, were from Ambo and Adea Berga.

##### 4.2.4.3. Calving intervals (CI)

As indicated by the survey result the estimated overall mean ( $\pm$ SD) of CI in the current study areas for both local and cross breed dairy cows, respectively, were  $26.6 \pm 7.6$  and  $13.4 \pm 2.2$  months. The shorter estimated mean ( $20.3 \pm 7.0$  months) and ( $13.1 \pm 1.9$  months) calving intervals, respectively, were from Adea Berga for both indigenous and crossbred dairy cows whereas the longest ( $24.40 \pm 7.9$  months) and ( $13.8 \pm 2.5$  months) calving intervals, respectively, were from Ambo for local and crossbred dairy cows.

##### 4.2.4.4. Days opens (DO)

The survey result revealed that the estimated overall mean ( $\pm$ SD) of DO for both local and cross breed dairy cows, respectively, were  $228.4 \pm 65.4$  and  $104 \pm 26.2$  days. The predicted shortest mean ( $\pm$ SD) ( $209 \pm 48.1$  days) and ( $100 \pm 21.9$  days) of days open, respectively, were recorded in Adea Berga for indigenous and crossbred dairy cows whereas the longest mean ( $252.1 \pm 75.7$  days) and ( $112 \pm 27.6$  days), respectively, were obtained from Walmera for both indigenous and cross breed cows.

#### 4.2.4.5. *Number of services per conception*

The predicted overall mean ( $\pm$ SD) of NSC in this study for both local and crossbred dairy cattle were  $3.2 \pm 1.6$  and  $1.9 \pm 1.1$  with ranges in between  $2.1 \pm 1$  and  $3.5 \pm 1.8$  for local cows whereas  $1.8 \pm 0.7$  and  $2.5 \pm 1.3$  for crossbred cows.

#### 4.2.5. *Lactation performance*

The survey results on estimation of lactation performance mainly average daily milk yield, lactation milk yield and lactation length of dairy herds are summarized in (Table 19).

##### 4.2.5.1. *Daily milk yield (DMY)*

The survey result of the present study revealed that the estimated average daily milk yields for local cows were 1.8, 2.2 and 1.7 liters per cow per day, respectively, required in Walmera, Adea Berga and Ambo with an overall average of 1.9 liters.

The predicted average daily milk yields shown by survey result in the current study for crossbred cows were 9.2, 11.2 and 9.9 liters per cow per day, respectively, recorded in Walmera, Adea Berga and Ambo with an overall average of 10 liters.

##### 4.2.5.2. *lactation milk yield (LMY)*

As indicated by the survey result the estimated overall average lactation milk yield for local cows was 514.5 liters per lactation per cow with values of 426.7, 559.6 and 557.3 liters per lactation per cow recorded in Walmera, Adea Berga and Ambo, respectively.

The survey result of this study indicated that the predicted average lactation milk yields for crossbred dairy cows were 2560.7, 3136.3 and 2871.2 liters per lactation per cow, respectively, required in Walmera, Adea Berga and Ambo with an overall average of 2856.1 liters per lactation cow.

##### 4.2.5.3. *lactation length (LL)*

In the present study, the survey results predicted that overall mean ( $\pm$ SD) of lactation length for local was  $278.2 \pm 10$  days with values of 251.5, 285.7 and 297.5 days per lactation, respectively, in Walmera, Adea Berga and Ambo.

The survey result of estimated overall mean ( $\pm$ SD) of lactation length for crossbred dairy cows was  $290.2 \pm 43.4$  days with values of 278.5, 293.8 and 299.2 days, respectively, in Walmera, Adea Berga and Ambo of the current study areas.

Table 19. Fertility traits and lactation performance Mean ( $\pm$ SD) of dairy cattle.

| Parameters   | Study areas       |                   |                   |                   |
|--------------|-------------------|-------------------|-------------------|-------------------|
|              | Walmera           | Adea Berga        | Ambo              | Overall mean      |
| <b>Breed</b> |                   |                   |                   |                   |
| <b>Local</b> |                   |                   |                   |                   |
| AFS          | 50.9 $\pm$ 10.3   | 47.9 $\pm$ 9.8    | 53.1 $\pm$ 13.8   | 50.6 $\pm$ 11.6   |
| AFC          | 59.9 $\pm$ 10.3   | 56.9 $\pm$ 9.8    | 62.9 $\pm$ 12.6   | 59.9 $\pm$ 11.2   |
| CI           | 23.1 $\pm$ 7.2    | 20.3 $\pm$ 7.0    | 24.4 $\pm$ 7.9    | 22.6 $\pm$ 7.6    |
| DO           | 252.1 $\pm$ 75.7  | 209 $\pm$ 48.1    | 224.1 $\pm$ 62.9  | 228.4 $\pm$ 65.4  |
| NSC          | 3.5 $\pm$ 1.5     | 2.5 $\pm$ 1.3     | 3.5 $\pm$ 1.8     | 3.2 $\pm$ 1.6     |
| DMY          | 1.8 $\pm$ 0.7     | 2.2 $\pm$ 1.3     | 1.7 $\pm$ 0.6     | 1.9 $\pm$ 0.9     |
| LL           | 251.5 $\pm$ 25.4  | 285.7 $\pm$ 11.2  | 297.50 $\pm$ 13   | 278.2 $\pm$ 10.8  |
| LMY          | 426.7 $\pm$ 64.6  | 559.6 $\pm$ 57.7  | 557.3 $\pm$ 58.5  | 514.5 $\pm$ 22.5  |
| <b>Cross</b> |                   |                   |                   |                   |
| AFS          | 20.5 $\pm$ 4.5    | 22.2 $\pm$ 6.1    | 19.9 $\pm$ 5.8    | 20.9 $\pm$ 5.6    |
| AFC          | 29.5 $\pm$ 4.5    | 31.2 $\pm$ 6.1    | 28.9 $\pm$ 5.8    | 29.9 $\pm$ 5.6    |
| CI           | 13.4 $\pm$ 2.1    | 13.1 $\pm$ 1.9    | 13.8 $\pm$ 2.5    | 13.4 $\pm$ 2.2    |
| DO           | 112 $\pm$ 27.6    | 100 $\pm$ 21.9    | 100 $\pm$ 27.4    | 104 $\pm$ 26.2    |
| NSC          | 1.8 $\pm$ 0.7     | 1.8 $\pm$ 1.6     | 2.1 $\pm$ 1       | 1.9 $\pm$ 1.1     |
| DMY          | 9.2 $\pm$ 3.2     | 11.2 $\pm$ 4.5    | 9.9 $\pm$ 3.5     | 10.1 $\pm$ 3.8    |
| LL           | 278.5 $\pm$ 37.5  | 293.8 $\pm$ 38.9  | 299.2 $\pm$ 50.7  | 290.2 $\pm$ 43.4  |
| LMY          | 2560.7 $\pm$ 31.7 | 3136.3 $\pm$ 53.1 | 2871.2 $\pm$ 26.4 | 2856.1 $\pm$ 23.8 |

*SD= standard deviation*

#### 4.2.6. Major reproductive disorders causing infertility in the study areas

As revealed by survey result the major reproductive disorders observed in the present study were repeat breeder, retained fetal membrane, abortion, calf mortality and still birth. In the present study, the repeat breeding has shown the higher prevalence whereas still birth recorded the lower prevalence in the study areas.

Table 20. Fertility disorders in dairy cattle in the study areas

| Parameters                     | Study areas |      |             |      |      |      |       |      |
|--------------------------------|-------------|------|-------------|------|------|------|-------|------|
|                                | Walmera     |      | Ade'a Berga |      | Ambo |      | Total |      |
|                                | N           | %    | N           | %    | N    | %    | N     | %    |
| <b>Repeat breeding</b>         |             |      |             |      |      |      |       |      |
| Yes                            | 54          | 90   | 45          | 75   | 49   | 81.2 | 148   | 82.2 |
| No                             | 6           | 10   | 15          | 25   | 11   | 18.8 | 32    | 17.8 |
| Total                          | 60          | 100  | 60          | 100  | 60   | 100  | 180   | 100  |
| <b>Calf mortality</b>          |             |      |             |      |      |      |       |      |
| Yes                            | 19          | 31.7 | 9           | 15   | 13   | 21.7 | 41    | 22.8 |
| No                             | 41          | 68.3 | 51          | 85   | 47   | 78.3 | 139   | 77.2 |
| Total                          | 60          | 100  | 60          | 100  | 60   | 100  | 180   | 100  |
| <b>Retained fetal membrane</b> |             |      |             |      |      |      |       |      |
| Yes                            | 20          | 33.3 | 11          | 18.3 | 18   | 30   | 49    | 27.2 |
| No                             | 40          | 66.7 | 49          | 81.7 | 42   | 70   | 131   | 72.8 |
| Total                          | 60          | 100  | 60          | 100  | 60   | 100  | 180   | 100  |
| <b>Abortion</b>                |             |      |             |      |      |      |       |      |
| Yes                            | 17          | 28.3 | 18          | 30   | 7    | 11.7 | 42    | 23.3 |
| No                             | 43          | 71.7 | 42          | 70   | 57   | 88.3 | 138   | 76.7 |
| Total                          | 60          | 100  | 60          | 100  | 60   | 100  | 180   | 100  |
| <b>Still birth</b>             |             |      |             |      |      |      |       |      |
| Yes                            | 6           | 10   | 14          | 23.3 | 10   | 16.7 | 30    | 16.7 |
| No                             | 54          | 90   | 46          | 76.7 | 50   | 83.3 | 150   | 83.3 |
| Total                          | 60          | 100  | 60          | 100  | 60   | 100  | 180   | 100  |

*N = number of observations*

The prevalence of abortion was varying at different stage of pregnancy in this study. As indicated in Figure (2) the occurrence of abortion was increased in dairy cows before three months of pregnancy whereas decreased after six months of pregnancy in all study areas. The 62.5%, 61.1% and 40% of respondents from Ambo, Adea Berga and Walmera stated that their cows were experiencing abortion before three months of pregnancy and only 11.1 % of respondents in the Adea Berga said their cows aborted after six months of pregnancy.

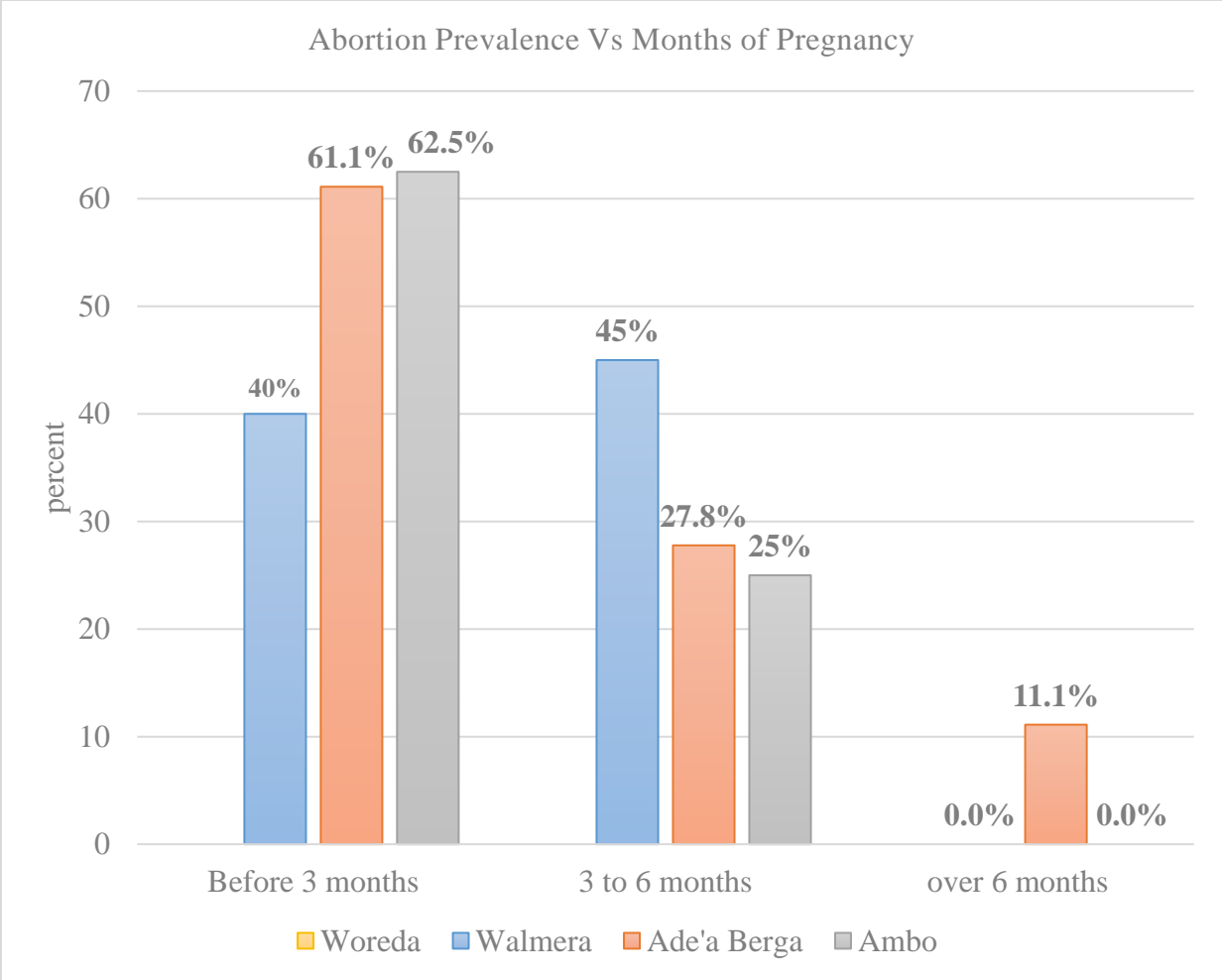


Figure 9. Abortion Prevalence Vs Months of Pregnancy in dairy cows within study areas.

## 5. DISCUSSION

### 5.1. On Station Study

#### 5.1.1. Fertility traits

The fertility of the breeding female is probably the single most essential factor that is a prerequisite for a sustainable dairy production system and influencing productivity. The most common indices of fertility traits are AFS, AFC, CI, DO and NSC.

##### 5.1.1.1. Age at first service (AFS)

The overall least square mean of AFS in the current study was similar with the finding of Haile *et al.* (2009b) for Borena and their crosses at the former Debre-Zeit research station of the ILRI and Holetta research center of dairy farm in the central Ethiopia and Berhanu and Chakravarty, (2014) for Borena × HF and Jersey breeds in central highlands of Ethiopia. This result of present study was also comparable with the report of Sisay, (2015) for Horro × Jersey crosses at Bako research center dairy farm.

Furthermore, the significance effect of genetic group and birth year on AFS was consistent with the finding of Getahun *et al.* (2019) and Nibo *et al.* (2021). The longest and shortest values AFS for HF× Borena crosses observed in the current was agreed with the report by Getahun *et al.* (2019) who reported the 50% F<sub>1</sub> genetic group had the shortest AFS whereas 50% F<sub>2</sub> had the longest value recorded. The least square mean ( $\pm$ SE) for AFS of pure Borena observed in this study was slightly comparable with the finding of Aynalem *et al.* (2011) for Borena cattle and their crosses at central Ethiopia.

Trend analysis shown that AFS on the basis of birth years fluctuate across the years. The shortest AFS recorded for animals born in 2012 to 2017 had while longest values have been scored in animals born 1976 to 1981. This is variation could be due to management fluctuation practices across the years, selection procedure and weather conditions had favored the trait in recent than earlier years.

Birth season had no significant effect on AFS and similar with the report of Lemma *et al.* (2010) and Getahun *et al.* (2019). This shows that birth season had no influence on puberty of heifers. However, this result was not agreed with the finding by Mengistu *et al.*, (2016) and Nibo *et al.* (2021) who reported season of birth significantly influenced AFS.

#### 5.1.1.2. Age at first calving (AFC)

The overall least square mean of AFC in present study was comparable with the finding of Berhanu and Chakravarty, (2014) for Borena × HF and Jersey at central highlands of Ethiopia; Getahun *et al.* (2019) for HF × Borena at Holeta research center dairy and Wassie *et al.* (2015) for HF × Borena and Arsi at Agarfa ATVET college dairy farm.

The shortest AFC observed in the current study among Borena × HF crosses was similar with the observation of Million *et al.* (2006) and Getahun *et al.* (2019), respectively, who reported 50% F<sub>1</sub> recorded the shortest AFC for HF crosses with local at Asella dairy station, Debre Zeit and Holeta research centers dairy farm and for HF × Borena crosses at Holeta research center dairy farm. Moreover, the shortest AFC observed in this study for Borena × Jersey crosses was consistent with the observation of Million *et al.* (2006) who found 50% F<sub>3</sub> recorded the shortest AFC for Jersey crosses with local breeds. The least square mean ( $\pm$ SE) of AFC for pure Borena recorded in this study was also consistent with the observation of Aynalem *et al.* (2011) for Borena cattle and their crosses at central Ethiopia.

The significance effect birth year on AFC trait in the current study was parallel to the finding of (Million *et al.*, 2010; Deriba, 2012 and Getahun *et al.*,2019). Trend analysis revealed that the shortest AFC observed in animals born in 2012 to 2017 whereas the longest values AFC was recorded for animals born in 1976 to 1981. This Variations could be attributed to change in management practices and fluctuation of weather conditions across the year.

The insignificance of birth season on age at first calving of heifers in the current study was agreed with the finding Million *et al.* (2006); Haile *et al.* (2009b) and Lemma *et al.* (2010) who reported season of birth had no significant effect on AFC. However, this result was inconsistent with the observation of Million *et al.* (2010); Deriba (2012) and Getahun *et al.* (2019) who discovered significant seasonal change on AFC. This variation might be due to difference in forage availability and quality and local weather conditions across the seasons.

#### 5.1.1.3. Calving intervals (CI)

The overall least square mean of CI in this study was longer than the finding of Kefena *et al.* (2011) for Borena × HF and Jersey in central tropical highlands of Ethiopia; Sisay (2015) for HF × Horro and Jersey at Bako research center dairy farm and Wassie *et al.* (2015) for HF × Borena and Arsi at Agarfa ATVET college dairy farm. Generally, this result of the present study was is longer than

the optimum calving interval of 365 days for a profitable dairy production. The variation of the current observation from others could be due to difference in feed quantity and quality, local climate conditions and management factors like heat detection ability. As suggested by Belay *et al.* (2012) the longer CI might be indicative of poor nutritional status, poor breeding management, lack of own bull and artificial insemination service, longer days open, diseases and poor management practices.

The shortest and longest CI obtained for Borena × HF crosses in the current study was consistent with report of Million *et al.* (2006) who found the shortest and longest CI, respectively, scored in 50% F<sub>1</sub> and F<sub>2</sub> genetic group for Borena × HF crosses at Asella dairy station, Debre Zeit and Holeta research center dairy farm. On the other hand, this result of current study was conflicting with the report of Getahun *et al.* (2019) found the 75% F<sub>2</sub> and F<sub>1</sub> genetic group, respectively, recorded the shortest and longest CI for Borena × HF at Holeta research dairy farm. The shortest and longest CI recorded among Borena × Jersey crosses in this study did not coincide with the report of Million *et al.* (2006) who found 75% F<sub>1</sub> and 50% F<sub>2</sub> genetic group, respectively, recorded the shortest and longest CI values. The least square means ( $\pm$ SE) of CI for pure Borena scored was longer than the observation of Million *et al.* (2006) for pure Borena cows. The difference in breed to recuperates after calving and adaptation to local climate and longer days open could be responsible for this variation. The longer calving intervals in the current study was shown on the cows with longer lactation length and days open.

The significant effect of calving year on CI in this study was in line with the observation of Haile *et al.* (2009b) for Borena × HF crosses at central Ethiopia; Getahun *et al.* (2019) for HF × Borena Holeta research center dairy farm and Nibo *et al.* (2021) for Jersey breed at Adea-Berga dairy research center. Trend analysis revealed that CI was fluctuated across the years. This Variation could be due to feed availability and quality and fluctuation in management practices across the years.

There was no marked significant effect of season on calving intervals of dairy cows in the present study, which is consistent with the finding of Haile *et al.* (2009b) who reported that no significance effect of season on CI. However, the result was conflicting with the finding of Getahun *et al.* (2019) and Nibo *et al.* (2021) who reported the significant of season on CI.

Calving intervals significantly influenced by parity of cows and similar with the report of Yohannes *et al.* (2016) and Getahun *et al.* (2019). The longest and shortest CI, respectively, was recorded in the 2<sup>nd</sup> and 10<sup>th</sup> parities. This variation could be due to increases in the ability of the animal to recover the uterine environment within shorter periods as age increase and adaptation to parturition and lactation stress.

#### 5.1.1.4. Days open (DO)

The overall least square mean of days open observed in the present was longer than the report of Haile *et al.* (2009b) for Borena × HF in the central Ethiopia at the former Debre Zeit research station of the ILRI and Holetta research center; Gizaw *et al.* (2011) for Horro × HF and Jersey at Bako research center dairy farm and Wassie *et al.* (2015) for HF × Borena and Arsi crosses at Agarfa ATVET college dairy farm. This variation between the current study and others authors might be because of difference in reproductive management like heat detection ability after calving and difference in feed quality during dry period.

The shortest DO observed by comparison among Borena × HF crosses in this study was similar with the observation of Getahun *et al.* (2019) who reported the shortest CI recorded in 75% F<sub>2</sub> genetic group for HF × Borena crosses at Holeta research center dairy farm. The least square mean for days opens of pure Borena recorded in current study was inconsistent with the finding of Aynalem *et al.* (2011) for pure Borena and Sisay (2015) for Pure Horro dairy cows. This variation could be due to difference in breed genetic potential, feed supply and local climate.

The significant effect of the calving year on days open trait observed in present study was in agreement with the observation of Deriba *et al.* (2015); Getahun *et al.* (2019) and Nibo *et al.* (2021). Trend analysis in the present study indicated that days open was fluctuated across the calving years. This variation could be because of difference in forage quantity and quality and management practices especially reproductive management across calving years.

The insignificance of season on days open trait has consistent with the earlier studies by Haile *et al.* (2009b); Deriba (2012); Mengistu *et al.* (2016). The significant effect of parity of cows on days open in this study was consistent with the finding Haile *et al.*, (2009b); Lemma *et al.* (2010); Deriba (2012) and Getahun *et al.* (2019). The highest days observe at 2<sup>nd</sup> parity in the present study could be because of lactation stress of cows in the early parity.

#### 5.1.1.5. *Number of services per conception (NSC)*

The overall least square mean for the NSC in the present study was slightly comparable with the result of Getahun *et al.* (2019) for HF× Borena at Holeta research center dairy farm and Sisay (2015) for Horro × HF and Jersey at Bako research center dairy farm. However, this result was lower than the finding of Haile *et al.* (2009b) for Borena × HF crosses in the central Ethiopia at the former Debre-Zeit research station of the ILRI and Holetta research center. This Variation might be due to breeds genetic performance, semen quality and difference in efficiency of AI technicians.

As shown in variance analysis NSC was significantly ( $P < 0.0001$ ) affected by genetic group and year of calving but, parity and season of calving had no significant effect on this trait, which in line with the finding of Mengistu *et al.* (2016) and Getahun *et al.* (2019). The lowest values of NSC observed by comparison between Borena × HF crosses in the current study was not agreed with the finding of Getahun *et al.* (2019) who reported the lowest NSC scored by 75% F<sub>2</sub> genetic group for Borena × HF crosses at Holeta research center dairy farm. This could be based on production performance of cows in a certain herd's management practice. High producing cows might be in stress and could not respond early for fertility traits. The adjusted mean for number of services per conception of pure Borena was observed in this study was lower than the finding of Haile *et al.* (2009b) for pure Borena cows.

The significance difference observed in the current study across period of calving might be due to variation in feeding availability, genetic groups and environmental fluctuation over the years.

#### 5.1.2. *Lactation performance*

The ultimate goal of dairy sectors genetic improvement programs in developing countries have focused on improving production performance of dairy cattle particularly, increasing production of milk yield. The most common traits of lactation performance of dairy cows are Daily Milk Yield (DMY), Lactation Length (LL) and Lactation Milk Yield (LMY).

##### 5.1.2.1. *Daily milk yield (DMY)*

The estimated overall least square mean ( $\pm$ SE) for daily milk yield recorded in the current study was lower than the finding of Gebreyohannes *et al.* (2014) for Borena × HF and Jersey crosses at the former Debre Zeit research station of ILRI; Bako and Holetta research centers dairy farms and Getahun *et al.* (2019) for HF × Borena crosses at Holetta research center dairy farm. This variation

of present result from others authors might be due to difference in breed genetic performance, feed quality and quantity, management practices and local weather conditions.

The significant for fixed effects of genetic group, calving year, season of calving and parity effect on daily milk yield was in line with the report of Getahun *et al.* (2019). The result observed by comparison of Borena × HF and Jersey crosses was consistent with the report of Gebreyohannes *et al.* (2013) who found that upgrading from 50% to higher grade HF crosses have shown no significant differences for daily milk yields. However, the result observed among Borena × HF genetic group in this study was not agreed with report of Getahun *et al.* (2019) and Haile *et al.* (2009a) who reported 75% F<sub>1</sub> genetic group had higher DMY for Boorena × HF at Holeta research center dairy farm. The number of observations investigated and variation in husbandry practices could be responsible for difference observation of the present study from others finding. The LSM for DMY of pure Borena found in this study was similar with the observation of Gebreyohannes *et al.* (2013) for pure Borena at the former Debre Zeit research station of the ILRI, Bako and Holetta research centers.

Trend analysis in the current study shown that the higher and lower DMY, respectively, recorded during the year 2012-2015 and 2004-2007. Factors could be responsible for this variation could be improving (upgrading) of blood level of herds, the fluctuation of weather condition, difference in feeding quantity and quality across the years.

The significant ( $P < 0.05$ ) difference showed on DMY traits among seasons was in agreement with the observation of Getahun *et al.* (2019) who reported inter seasonal change of weather condition and management also showed significant difference for daily milk yield among seasons.

The significant difference observed among parity of cows in this study could be due to increase in age of cows. Cows produce more milk as their age increased as shown in the current result or daily milk yield was increased as parity increase.

#### 5.1.2.2. Lactation length (LL)

The estimated overall mean of LL in this study was lower than the observation of Haile *et al.* (2009a) for Borena × HF in the central of Ethiopia at the former Debre-Zeit research station of the ILRI and Holetta research center dairy farm; Kefena *et al.* (2011) for Borena × HF and Jersey crosses in the central tropical highlands of Ethiopia; Getahun *et al.* (2019) for HF × Borena crosses

at Holeta research center dairy farm. Breed genetic potential, feed quality, number of observations studied could be cause of the variation of the current report from other scholars reported elsewhere.

The significant of fixed effects for genetic groups, year of calving and parities on lactation length observed in current study was similar with the finding of Getahun *et al.* (2019) but, the significance of season of calving was not agreed. The longest and shortest LL observed between Borena × HF and Jersey crosses in this study was somewhat similar the finding of Gebreyohannes *et al.* (2013) who found the shortest and longest LL, respectively, recorded with 50% F<sub>1</sub> and 75% F<sub>1</sub> generation for Borena × HF and Jersey at the former Debre- Zeit research station of the ILRI, Bako and Holeta research centers. However, the current result of this study was conflicting with the finding of Getahun *et al.* (2019) who reported the 75% F<sub>2</sub> and F<sub>1</sub> generations, respectively, scored the shortest and longest LL for Borena × HF at Holeta research center. The estimated LSM for LL of pure Borena in this study was slightly comparable with the finding of Gebreyohannes *et al.* (2013) for pure Borena at the former Debre-Zeit research station of the ILRI, Bako and Holetta research centers dairy farms.

Lactation length based on calving year was decreased from 1984-1987 to 2016 to 2019 as shown in trend analysis. However, there was no significant values were observed between year 1988 to 1991 and 1996 to 1999 and between 2000 to 2003 and 2004 to 2007. This variation might be associated to fluctuations in feed quantity and quality or climate (weather) over the years

The lactation length trait was significantly ( $P < 0.05$ ) affected by the season of calving and consistent with the finding of Kefena *et al.* (2006b); Haile *et al.*, (2009a); Getahun *et al.* (2019).

The decreasing pattern of lactation length observed as parity increased (from one to ten) in the current study was similar with the observation of Haile *et al.* (2009a and Deriba (2012).

#### 5.1.2.3. Lactation milk yield (LMY)

The overall least square mean for LMY in the present study was lower than the report of various studies Haile *et al.* (2009a) for Borena × HF crosses in the central Ethiopia; Kefena *et al.* (2011) for Borena × HF and Jersey crossbred in the central highlands of Ethiopia and Getahun *et al.* (2019) who report for Borena × HF crosses at Holeta research center. The feeding availability and quality, local climate effect, production system and number of observations studied could be cause of the variation of the current report from other scholars reported elsewhere.

The higher LMY observed between Borena × HF crosses in the current study was in agreement with the finding of Haile *et al.* (2009a); Gebreyohannes *et al.* (2013) and Getahun *et al.* (2019) who reported the higher LMY scored by 75% F<sub>1</sub> generation for Borena × HF crosses at the central Ethiopia and Holeta research center. However, for Borena × Jersey crosses this result of the current study was contradicted with the report of Gebreyohannes *et al.* (2013) who found the higher LMY in 75% F<sub>1</sub> generation for Borena × Jersey crosses at the former Debre- Zeit station of the ILRI, Bako and Holetta research center. This variation might be due to difference in breeds composition, lactation stages and herds sizes. The estimated least square mean for LMY of pure Borena cows observed in the current study was lower than the report of Gebreyohaanes *et al.* (2014) for pure Borena at Bako and Holetta research centers dairy farm.

The significant difference observed in lactation milk yield across the years in the present study might be associated to changes in herd's management practices and fluctuation of the weather condition over the years.

Lactation milk yield was sensitive to seasonal variation as indicated in this result and in line with the report of Getahun *et al.* (2019). This seasonal variation of lactation milk yield observed was might be due to variation in feed quality and quantity and management practices across the seasons.

The significant effect of parity on milk yield per lactation found in this study was similar with the finding of Haile *et al.* (2009a); Gebreyohannes *et al.* (2014); Getahun *et al.* (2019). Milk yield per lactation was increased from parity one to four and from parity eight to ten. However, it was decreased from parity five to seven. This variation could be related to the age of cows in which as age increased LMY also increased.

## **5.2. On-farm study**

### *5.2.1. Household characteristics*

The highest educational level of the respondents in the current study was higher education which might be related to the availability of different agricultural institutions. Similarly, Abebe *et al.* (2017) reported that first degree was the highest educational level achieved by household heads in the central highlands of Ethiopia.

The highest percentages of male household heads observed in the current study was similar to report of Zewdie (2010) who found 86.7% male and 13.3% female in the central highlands; Fekede *et al.* (2013) who reported 84.4% male and 16.6% female in the central highlands.

The average family size of the study areas was comparable with observation of Sintayehu *et al.* (2008) who reported 7.4 and 6.0 persons per household, respectively, reported from shashamene and Dilla. The average family sizes of the three districts were also higher than national average family size of 4.8 persons per HH (CSA, 2018). The higher family size may be useful for different routine dairy farm activities such as feeding, cleaning, herding, milking and milk processing. However, the average family size revealed in this survey was somewhat larger than the finding of Abebe *et al.* (2017) who reported 4.4 persons per HH from different areas of the central Ethiopia.

Overall survey result of dairy farm owner stated dairy production as their major occupation in the present study was comparable with the report of Shibru and Mekasha (2016) who found 13.7% of farmers involvement in dairy production in Sebeta Awsa area. However, the current result of this study was lower than the finding of Girma *et al.* (2014) who reported 29.2% of respondents in Shashamane were dairy cow producers. The variation observed in current study from others could be due to differences the demand for dairy production.

### *5.2.2. Dairy herds management practices in the study areas*

#### *5.2.2.1. Feeding system and feed supplements for dairy herds*

The survey result of feeding system found in the present study was slightly comparable with the finding of Dessalegn *et al.* (2016) who reported 74.6% and 25.4% of the dairy owners in Bishoftu and Akaki towns, respectively, use stall feeding and stall feeding with limited grazing feeding systems as the main feeding practices. Parallel to the feeding system observed in Ambo woreda of the current study, Girma *et al.* (2014) found that stall feeding practiced in urban areas in and around Shashamane town.

#### *5.2.2.2. Housing and recording keeping practices*

In the current study, the housing system practiced in the study areas was consistent with the observation of Ayalew (2017) who reported all of the respondents used separate houses for their dairy cattle in Dessie town of Ethiopia. Furthermore, (Hulagersh *et al.*, 2017) reported 80% farmers used separate housing systems in urban and peri-urban dairy farms of Mekelle, Ethiopia.

contradicting the current findings, Asrat *et al.* (2013) reported 60% of dairy producers used the same residence for family and animals in the urban dairy production system of Boditti town. The differences might be because of variations in management systems, farm type and financial related problems.

In the current study, the survey result of records keeping practices in the study areas were similar with the finding Asrat *et al.* (2013) who reported 95% of dairy farmers were not practicing record keeping in and around Boditti town, South Ethiopia.

#### *5.2.2.3. Frequency of watering dairy cattle*

The water provision of dairy producers in the current study areas was similar to the finding of Zewdie (2010) and Ayeneshet *et al.* (2017), respectively, who reported dairy producers in the highland (Debre Birhan, Jimma, and Sebeta) watered their cattle twice a day on average and in Alefa district in North Gondar zone watered their dairy cattle twice. Parallel to the survey result in Ambo woreda of the current study, Tilahun and Gebregiorgis (2016) noted that respondents were watered their animals once a day in Mekelle city. The overall survey result of water provision of dairy producers in the present study was consistent with the results of Alemshet (2014) who found respondents in urban and in peri-urban areas provide water ad libitum for dairy cattle in Adigrat, Tigray.

#### *5.2.3. Breeding practices in study areas*

##### *5.2.3.1. Experience and purpose of keeping dairy cattle*

The overall survey result of experience in dairy keeping in this study was comparable to the observation of Solomon (2014) who reported 41.7% of dairy farms were established about 6 to 10 years ago in Mekelle city. The current assessment in Walmera and Adea Berga, was similar with the report of Quddus, (2017) who found the majority of the dairy producers had 10 to 19 years of experiences in dairy farming in Bangladesh.

The primary purpose of keeping dairy cattle in current study areas was in line with the report of Sintayehu *et al.* (2008) who observed market-oriented milk production systems in Ethiopia; Belay and Geert (2016) who revealed that the primary reason for keeping dairy cattle was the milk production for income generation in Jimma town.

#### 5.2.3.2. *Mating system*

The survey revealed that farmers have a different practice in using mating system in which 46.7% in Ambo area practiced only artificial insemination while 70% and 60% of respondents in Walmera and Adea Berga respectively, practiced AI and natural mating. In the study areas, there was a tendency that mating practices have shifted from natural mating to improved mating system. As revealed by the survey result, artificial insemination solely and artificial insemination with natural mating was commonly practiced in the study areas.

#### 5.2.4. *Fertility traits*

##### 5.2.4.1. *Age at first service (AFS)*

The survey finding declared that the estimated overall mean of AFS for indigenous heifers was longer than the report of Ayantu *et al.* (2012) for Horro breed heifers in Horro Guduru Wollega Zone; Megersa (2016) and Bayissa *et al.* (2017) for indigenous heifers in two districts of West Shoa Zone. The estimated mean of AFS for each district of the present study areas were shorter than the report Bayissa *et al.* (2017) for local heifers in Gindeberet and Abuna Gindeberet districts of West Shoa Zone. The estimated mean of AFS observed in Walmera was longer than the finding of Ketema *et al.* (2018) who reported for local heifers in Walmera districts. This variation could be due to the difference in breed genetic performance, feed quality and availability and local climate condition.

The result of estimated overall mean of AFS for crossbred heifers in the current study was shorter than the finding Megersa (2016) and Bayissa *et al.* (2017) for crossbred heifers in two districts of West Shoa Zone. The estimated mean of AFS in each current study areas were comparable with the finding of Dessalegn *et al.* (2016) for crossbred dairy heifers in Bishoftu and Akaki towns. However, these results of current study were shorter than the report of Zewdie (2010) for crossbred heifers in the highlands and the central rift valley of Ethiopia; Bayisa *et al.* (2017) in Gindeberet and Abuna Gindeberet districts of West Shoa Zone and Ketema *et al.* (2018) for crossbred heifers in Walmera districts. The longer AFS predicted in this study could be due to poor breed genetic potential, unfavorable local climate, poor feed supply and late time insemination.

##### 5.2.4.2. *Age at first calving (AFC)*

The survey result indicated that the estimated overall mean of AFC for local heifers in the current study was slightly comparable with the finding of Ayantu *et al.* (2012) for Horro breed heifers in

Horro Guduru Wollega Zone and Bayissa *et al.* (2017) for indigenous heifers in two districts of West Shoa Zone. The predicted mean of AFC reported by Bayisa *et al.* (2017) for local heifers in Gindeberet and Abuna Gindeberet districts, respectively, were similar with the current survey finding in Adea-Berga and Walmera districts for local heifers. The estimated mean of AFC observed in Walmera district of current study area was longer than the report of Ketema *et al.* (2018) in Walmera district for local heifers.

The predicted overall mean of AFC for crossbred heifers in this study was shorter than previous Studies by Bayissa *et al.* (2017) for crossbred heifers at two districts of West Shoa Zone. The estimated mean of AFC in each district of the current study areas were nearly similar with the finding of Desalegn *et al.* (2016) for crossbred heifers under small scale dairy productions in Bishoftu and Akaki. On the other hand, the estimated mean of AFC for crossbred dairy heifers in the current study areas were shorter than these results of Hunduma (2012) for crossbred in Assela; and Bayissa *et al.* (2017) for crossbred dairy heifers in Gindeberet and Abuna Gindeberet districts. The variation in AFC observed in the present study with others authors might be due to difference in Adaptation to local climate, management practices and feed supply.

#### 5.2.4.3. Calving intervals (CI)

The estimated overall mean of calving interval for local cows in the current study was comparable with the observation Bayissa *et al.* (2017) for local cows in two districts of West Shoa Zone. However, this result was shorter than the observation of Megersa (2016) for indigenous cows in under rural dairy farming system in West Shoa Zone. Furthermore, the current result was longer than the report of Ketema *et al.* (2018) for local dairy cows in Walmera district. This variation might be due to the differences in breed recuperate after calving, mating system and management practices.

The predicted overall mean of CI for crossbred dairy cows in the present study was comparable to the observation of Hunduma *et al.* (2012) for crossbred dairy cows under smallholder condition in Aseela, Ethiopia. However, the current survey result was shorter than the report of Megersa (2016) and Bayissa *et al.* (2017) for two crossbred cows in West Shoa Zone. The estimated mean of CI in each current study areas were similar with the report Dessalegn *et al.*, (2016) for crossbred dairy cows in Bishoftu and Akaki towns. However, the present results were shorter than the finding of

Bayissa *et al.* (2017) for crossbred in Gindeberet and Abuna Gindeberet and Ketema *et al.* (2018) for crossbred cows in Walmera district. Improper feeding and management practices, prolonged days open, a poor breeding system, and diseases might all contribute to the variance. This could be because of genetic difference between the indigenous and crossbred as well as less attention paid to native cow breeds in management practices compared to crossbreds.

The CI for crossbred dairy cows in the current study was also similar with the optimum calving interval of 12 to 13 months on different literatures. This was indicative of good nutritional status, good breeding management and shorter days open, diseases and good management practices.

#### 5.2.4.4. Days open (DO)

The predicted overall mean of DO for local dairy cows in the current study was shorter than the observation of Megersa (2016) for indigenous cattle in West Shoa Zone. On the other hand, the current survey result was longer than the finding of Bayissa *et al.* (2017) for local dairy cows in two districts of West Shoa Zone. The estimated mean of calving to conception for local dairy cattle in the current study areas were longer than study of Bayissa *et al.* (2017) for indigenous dairy cows in Gindeberet and Abuna Gindeberet and Ketema *et al.* (2018) for local cows in Walmera district.

The predicted overall mean of DO for crossbred dairy cows in the current study was slightly comparable with the finding of Bayissa *et al.* (2017) for crossbred dairy cows in two districts of West Shoa Zone. The Estimated mean of calving to conception intervals in the three districts of present study areas of this study for crossbred dairy cows were shorter than the study of Bayissa *et al.* (2017) for crossbred dairy cows in Gindeberet and Abuna Gindeberet and Ketema *et al.* (2018) for 50% and above 50% crossbred cows in Walmera district. Poor and insufficient feeds, poor heat expression and detection after calving might all contribute to the differences.

#### 5.2.4.5. Number of services per conception (NSC)

The survey result of estimated overall mean of NSC in this study was higher than the report of Kumar *et al.* (2014); for local cows under smallholder condition in Mekelle city and Assemu *et al.* (2016) for Fogera cattle. The poor services per conception might be indicative of the presence of many repeats breeding cows in the dairy farms included in the study. This poor NSC might also attribute to incorrect timing of insemination, poor quality of semen, poor efficiency of the inseminator could negatively affect the success of insemination.

The estimated overall mean of NSC for crossbred cows in the current study areas was slightly comparable with the finding of Million *et al.* (2010) in tropical conditions of crossbred cows. Moreover, the estimated mean of NSC in Walmera and Adea Berga of the present study areas were similar with this finding.

#### 5.2.5. *Lactation performance*

##### 5.2.5.1. *Daily milk yield (DMY)*

The survey result of estimated overall average daily milk yield for local cows in the current study was in line with the study by Bainsegn (2015) for local cows in three districts of West Shoa Zone. However, this result was higher than the observation of Bayissa *et al.* (2017) for indigenous cows in two districts of West Shoa Zone. The predicted survey result of milk yield per day for local dairy cattle in the three current study areas were parallel to the study by Bainsegn (2015) for local cows in Adaberga, Ejere and Metarobi; Azage *et al.* (2009) for indigenous cows in Adaberga and Metarobi. Furthermore, the estimated mean of DMY for local dairy cattle in Walmera in this study was similar with the report of Ketema *et al.* (2018) for indigenous cows in Walmera districts. On the other hand, the current survey results were higher than the report of Bayissa *et al.* (2017) in Gindeberet and Abuna Gindeberet for local cows. The estimated average DMY of local cows in the present study was higher with the value reported by CSA, (2020/21) which was 1.48 liters for the country.

The current an overall average daily milk yield for crossbred cows was similar with the report of Kiros., (2019) in urban and peri-urban Holetta and urban Sululta. However, this result was higher than the report of Bainsegn (2015) and Bayissa *et al.* (2017) in West Shoa Zone for local cows. An estimated mean of DMY for crossbred dairy cows in the current study areas were slightly comparable to the study by Bainsegn (2015) in Adaberga, Ejere and Metarobi for crossbred cows. The survey result of predicted milk yield per cow/day in the present study areas were within the finding of Azage *et al.*, (2013) for crossbred dairy cows in urban systems reported in Ethiopia. The Present average daily milk yield reported Adea Berga was similar to the finding of Dessalegn *et al.* (2016) for crossbred dairy cows in Bishoftu town and Kiros, (2019) in urban and peri-urban in Bishoftu town.

#### 5.2.5.2. *Lactation milk yield (MYL)*

The present survey results of an overall average lactation milk yield of local cows were higher than reported by Melku (2017) for local cows in West Gojam Zone.

From the analyzed collected survey data, the estimated overall average lactation yield of crossbred in the current study was less than observations were reported by Haile *et al.* (2009a) for Borena × HF crosses in the central, Ethiopia; Kefena *et al.*, (2011) for Borena × HF crossbred in central highland of Ethiopia; Mulugeta *et al.* (2014) for HF x local in West Shoa. The overall mean result obtained in this study was higher than the report of Kumar *et al.* (2014) for crossbred in Gondar, Ethiopia. The Variation of the current result from different areas reported could be associated with breed/genetic makeup, management, feeding practice and climate factor in which animals were managed.

#### 5.2.5.3. *Lactation length (LL)*

The survey result shown that the estimated overall mean of LL for local cows in this study was shorter than the study Bainsegn (2015) for local cows at three districts of West Shoa Zone; Megersa (2016) for local cows under different production system in West Shoa Zone and Bayissa *et al.* (2017) for local cows in two districts of West Shoa Zone. The estimated average LL in the present study areas were shorter than the report of Bainsegn (2015) for indigenous cows in Adaberga, Ejere and Metarobi. Similarly, the estimated average LL in Adea Berga and Ambo were shorter than the finding of Bayissa *et al.* (2017) in Gindeberet and Abuna Gindeberet for local cows. The estimated average LL reported by Ketema *et al.* (2018) was shorter than the current result in Walmera. In this study, the average lactation length of the indigenous cows reported was higher than the national average of 7 months (CSA, 2020/21). In general, poor genetic potential, shortage of feed and the prevalence diseases of the investigated population were responsible may be for the variation in lactation length in the current study.

The predicted survey result of average of LL for crossbred cows was comparable with the study by Bainsegn (2015) for crossbred cows in the three districts of West Shoa Zone. However, this result was longer than the finding of Bayissa *et al.* (2017) in Gindeberet and Abuna Gindeberet districts of West Shoa Zone for crossbred cows. The estimated survey results of average LL in Adea Berga and Ambo of the present study areas were longer than that reported by Baisegn (2015) in Adaberga and Metarobi but, shorter than in Ejere. The average LL in Walmera was shorter than

that reported by Ketema *et al.* (2018) for 50% and above 50% crossbred cows in Walmera. This variation could be due to difference in feed availability and quality and diseases prevalence.

#### 5.2.6. Major reproductive disorders cause infertility in the study areas

Out of 180 respondents 82.2%, 27.2%, 23.3% ,22.8 % and 16.7%, respectively, stated that the major fertility disorders affected dairy cows were repeat breeding, retained fetal membrane, abortion, calf mortality and still birth. This result was comparable with the finding of Adane *et al* (2014) who reported abortion, repeat breeding and RFM as the major reproductive disorders in Hossana, Southern Ethiopia, Gashaw *et al.* (2011) who reported abortion, repeat breeder, RFM and anestrus were the major reproductive disorders in Central Ethiopia.

The prevalence of repeat breeding observed in Walmera, Adea Berga and Ambo in the present study were comparatively higher than the finding by Adane *et al.* (2014) and Alemselem *et al.* (2015) who reported 13.08% and 21%, respectively. Farmers in the study areas practice different options to reverse failure on conception. If AI service did not bring conception, most of the respondent practice natural mating while some of them practice AI repeatedly. Some of respondent stated that for their cow's failure to conceive they offers compounded or improved feeds with high salt content and quarter kilogram of *Bikil* every morning for three days to get them in heat again. Cows fed *Bikil* every morning for three days come in heat within a week or ten days as mentioned by some respondents in the study areas. As stated by some dairy cattle producers, cows offered compounded or improved feeds with high salt content come in heat soon than cows offered compounded or improved feeds without salts. As indicated by survey result the reason for failure of insemination in the study areas was late timely inseminations or heat detection problem, poor semen quality, inappropriate semen handling, poor genetic performance and poor efficiency of AI technicians. This is in line with the result of (Desalegn, 2008) in Ethiopia.

The prevalence of retained fetal membrane (RFM) observed in the current study in Walmera and Ambo were higher than the report of Abreham *et al.* (2010) in Addis Ababa milkshed. The variation in prevalence of RFM might be difference in feed supply and management practices. However, prevalence of RFM observed in Adea Berga was nearly agree with report by Gashaw (2011) in the central Ethiopia. The respondents in the study areas said that they call animal health technicians or veterinarians to treat their cows encountered with retained fetal membrane. According to some dairy producers in the study areas, they traditionally aid or treated their cows

encountered RMF by grinding lean seed cake and diluting it with water, then drinking the cows that fail to shed the fetal membrane.

The prevalence in the current study of abortion in Walmera, Adea Berga and Ambo were greater than the findings of Hunduma (2013) in Asela town. This variation could be due to nutritional deficiencies. As stated by the respondents in present study, the occurrence of abortion was higher before three months of pregnancy in Walmera, Adea Berga and Ambo

In this study, prevalence of stillbirth was occurrence rate in the current study areas were higher than the findings of Abreham *et al.* (2010) for crossbred dairy cow under smallholding in Addis Ababa milk shed. This variation could be due to the poor management during pregnancy and parturition.

## 6. CONCLUSIONS AND RECOMMENDATIONS

### 6.1. Conclusion

The fixed effects genetic groups, birth year groups, calving year groups and parity in the current study have shown significant variation on the fertility and productive traits estimated.

There were apparent variations observed among the genetic groups compared. The better fertility traits like early first service and calving, shorter calving intervals and days open was recorded in 50% F<sub>1</sub> and 75% F<sub>2</sub> generation, respectively, for Borena × HF and Jersey crosses. Furthermore, 50% F<sub>2</sub> and 75% F<sub>1</sub> were recorded poor fertility traits. Compared to second generation crosses milk yield was higher in the first-generation crosses and the breed of choice for milk production trait compared with other genetic groups. It might be concluded that the 50% F<sub>1</sub> crossbred dairy cows performed better in all traits investigated compared to the crossbred 50% F<sub>2</sub>, F<sub>3</sub>, and 75% F<sub>1</sub>, F<sub>2</sub>.

Fertility traits are not significantly affected by inter seasonal change. However, productive traits are sensitive seasonal variation. The better milk production was observed on cows calved during dry season and main rainy season. In the current study, calving intervals, days open, milk yield and lactation length had significantly influenced by parity the cows. As parity increased calving intervals, days open and lactation were decreased. Milk yield fluctuate as parity of cows increased.

In general, the estimated overall mean of fertility traits for indigenous dairy cows in the current study were poor when compared to the finding reported in some regions of Ethiopia and ideal standards. On the other hand, the overall mean of fertility traits except NSC for crossbred dairy cows were in parallel with finding reported in some parts of Ethiopia and optimum standard.

The major reproductive disorders that were causes of infertility observed in the present study were repeat breeder, retained fetal membrane, abortion, calf mortality and still birth. Repeat breeding shown the higher prevalence whereas still birth rate the lower prevalence. The ultimate goal dairy herd production is to increase milk yield and manipulate early first service and calving, lower calving interval and days open, decrease the number of services per conception. However, repeat breeder, retained fetal membrane, abortion, calf mortality, still birth were the major causes of infertility of dairy cows.

## 6.2. Recommendations

Based on this study the following recommendations were forwarded;

- ❖ According to the findings of this study, 50% F<sub>1</sub> crossbreds should be the better generation for future breeding policy in improving fertility and production traits.
- ❖ The year of calving and births has been found to affect the fertility traits and lactation performance of the existing breed, the irregular management practice should be given special attention.
- ❖ Further on-farm assessment and evaluation that spans a broader region should be done to evaluate the fertility and productive traits of dairy herds for optimal exploitation of existing breeding programs and to uncover possible causes of reproductive disorders.
- ❖ Adequate feeding system and keeping the health conditions of dairy cattle should be employed to ensure improvement in both fertility and productive traits.

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- D) Concentrate \_\_\_\_\_  
 E) Others specify \_\_\_\_\_
- 3.6. Do you use feed supplements for your dairy cattle? A) Yes B) No
- 3.7. If yes, types of concentrate mix used for your dairy cattle?  
 A) wheat middling and wheat bran B) noug cake C) maize flour D) Salt E)  
 others (specify) \_\_\_\_\_
- 3.8. Class of dairy animals provided supplements  
 A) Dry B) Lactating C) Calves D) Heifers
- 3.9. Frequency of providing feed supplements for dairy cows  
 A) Once a day B) Twice a day C) No supplements
- 3.10. When you mostly supplement your dairy cows?  
 A) Early pregnancy B) Mid pregnancy C) Late pregnancy D) During milking  
 period E) During dry period F) Other \_\_\_\_\_
- 3.11. How frequently do you provide water for dairy cattle/cows?  
 A) Once a day B) Twice a day C) Three times a day D) Roam freely
- 3.12. Is there separate house for dairy cattle? A) Yes B) No
- 3.13. If yes what is the housing type for dairy cattle?  
 A) Open sided house B) Closed sided house C) No separate house
- 3.14. If no separate house, how you keep them?  
 A) Together with other animals B) Together with family C) Freely in the  
 compound
- 3.15. Dairy farm sanitation  
 A) Good B) Fair or medium C) Dirty looking D) Difficult to judge
- 3.16. Is there recording system in your farm? A) Yes B) No
- 3.17. If yes, what parameters are recorded?  
 A) \_\_\_\_\_  
 B) \_\_\_\_\_  
 C) \_\_\_\_\_  
 D) \_\_\_\_\_
- 3.18. Do you practice culling? A) Yes B) No
- 3.19. If yes, why do you cull? A) Age B) Infertility C) Poor production D)  
 Diseases E) Financial difficulties F) Others(specify) \_\_\_\_\_
- 3.20. Type of farm: A) intensive B) semi-intensive C) extensive

#### 4. ASSESSMENT ON REPRODUCTIVE PERFORMANCE OF DAIRY HERDS

4.1. Fill out the production and reproduction parameters of lactating cows

| Traits  | Breeds |         |
|---|--------|---------|
|   | Local  | crosses |
| Average age at first service (in months)            |        |         |
| Average age at first calving (in months)            |        |         |
| Intervals between last two calving (in months)      |        |         |
| Intervals from calving to conception (in months)    |        |         |
| Service per conception (in numbers)                 |        |         |
| Average daily milk production (liters/day)          |        |         |
| Times in lactation (total days in lactation)        |        |         |
| Average milk yield per lactation (liters/lactation) |        |         |

4.2. Types of mating system in your farm? A) Natural B) AI C) both

4.3. If yes, what do you think the cause/s for the animal failure to conceive?

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4.4. What measure did/do you take to get the animal pregnant?

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## 5. REPRODUCTIVE DISRDRERS ON DAIRY HERDS

- 5.1. Any of your cattle encountered reproductive diseases or problems recently? A) Yes  
B) No
- 5.2. If yes, what reproductive diseases or problems were observed?  
\_\_\_\_\_  
\_\_\_\_\_
- 5.3. \_\_\_\_\_
- 5.4. Have any of your cows or heifers been repeat breeder? A) Yes B) No
- 5.5. Did any of your cows suffer from abortion? A) Yes B) No
- 5.6. If yes, what month of the pregnancy abortion was occurred?  
A) Before 3 months B) 3 to 6 months C) Over 6 months
- 5.7. Did any of your cows encounter delayed pregnancy in recently? A) Yes B) No
- 5.8. Did any of your cow's or heifers give birth to a dead calve at a normal gestation length (9 months)? A) Yes B) No
- 5.9. If yes, how many cows? \_\_\_\_\_
- 5.10. If yes, at which parity cows give birth to a dead calve?  
A) Parity 1 – 3 B) Parity 4 – 6 C) Parity 7 - 10
- 5.11. Did any of your calf (under a year old) dead? A) Yes B) No
- 5.12. If yes, how many calves? \_\_\_\_\_
- 5.13. If yes, what do you think the main cause/s for calf death?  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_
- 5.14. Did any of your cow's encounter retained fetal membranes? A) Yes B) No
- 5.15. If yes, how did you solve the problem?  
\_\_\_\_\_  
\_\_\_\_\_
- 5.16. Did any of your animals come to estrus, but missed insemination or mating? A)  
Yes B) No
- 5.17. If yes, why was the animal not inseminated or mated?  
A) Lack of bull B) Lack of AI technician C) Reproductive tract problem  
D) Size of the animal was very small to breed E) Lack of nutrition F)  
Others causes (specify) \_\_\_\_\_
- 5.18. What is your future plan to improve the reproductive performance of your animals?  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

**Appendix B 1.** Analysis of variance of age at first service (AFS).

| Source of variation | DF   | Type III SS | Mean Square | F value | Pr. > F |
|---------------------|------|-------------|-------------|---------|---------|
| Year group          | 7    | 13840.60161 | 1384.0616   | 23.15   | <.0001  |
| Season group        | 2    | 513.44211   | 256.27105   | 2.42    | 0.0890  |
| Genetic group       | 10   | 17158.3839  | 2451.19770  | 13.07   | <.0001  |
| Error               | 1304 | 115397.8043 | 105.8695    |         |         |

**Appendix B 2.** Analysis of variance of Age at First Calving (AFC).

| Source of variation | DF   | Type III SS | Mean Square | F value | Pr. > F |
|---------------------|------|-------------|-------------|---------|---------|
| Error Year          | 7    | 18084.45174 | 2583.50596  | 35.12   | <.0001  |
| Season group        | 2    | 239.38956   | 119.69478   | 1.63    | 0.1970  |
| Genetic group       | 10   | 15399.39179 | 1539.93918  | 20.93   | <.0001  |
| Error               | 1317 | 79516.4918  | 20218.0     |         |         |

**Appendix B 3.** Analysis of variance of Calving Interval (CI).

| Source of variation | DF   | Type III SS | Mean Square | F value | Pr.>F  |
|---------------------|------|-------------|-------------|---------|--------|
| Genetic group       | 10   | 2890697.100 | 28069.710   | 14.30   | <.0001 |
| Season group        | 2    | 6074657.865 | 867808.266  | 42.92   | 0.1884 |
| Year group          | 7    | 67522.153   | 33761.076   | 1.67    | <.0001 |
| Parity              | 9    | 3113779.440 | 345975.499  | 17.11   | <.0001 |
| Error               | 5408 | 100705591.9 | 20218.0     |         |        |

**Appendix B 4.** Analysis of variance of Days Open (DO).

| Source of variation | DF   | Type III SS  | Mean Square | F value | Pr.>F  |
|---------------------|------|--------------|-------------|---------|--------|
| Genetic group       | 10   | 3109878.917  | 310987.892  | 15.48   | <.0001 |
| Year group          | 7    | 5548598.737  | 792656.962  | 39.47   | <.0001 |
| Parity              | 2    | 75869.581    | 37934.750   | 1.89    | <.0001 |
| Season group        | 9    | 32229049.312 | 358783.257  | 17.86   | 0.1514 |
| Error               | 5380 | 10004346.31  | 20008.50    |         |        |

**Appendix B 5.** Analysis of variance of Number of Service per Conception (NSC).

| Source of variation | DF   | Type III SS  | Mean Square | F value | Pr. > F |
|---------------------|------|--------------|-------------|---------|---------|
| Genetic group       | 10   | 113.0210277  | 11.3210277  | 5.99    | <.0001  |
| Parity              | 9    | 36.8089990   | 4.0898888   | 2.7     | 0.215   |
| Year group          | 7    | 44.2745666   | 6.3249381   | 3.35    | 0.0014  |
| Season group        | 2    | 4.0288915    | 2.0144457   | 1.07    | 0.3441  |
| Error               | 5490 | 951605.46853 | 1888.106    |         |         |

**Appendix B 6.** Analysis of variance of Daily Milk Yield (DMY).

| Source of variation | DF   | Type III SS | Mean Square | F value | Pr. > F |
|---------------------|------|-------------|-------------|---------|---------|
| Genetic group       | 10   | 17686.52606 | 1768.65261  | 663.66  | <.0001  |
| Parity              | 9    | 393.92665   | 43.76963    | 16.42   | <.0001  |
| Year group          | 8    | 711.96640   | 88.99580    | 33.39   | <.0001  |
| Season group        | 2    | 40.89645    | 20.44823    | 7.67    | 0.005   |
| Error               | 3888 | 905834.362  | 266.500     |         |         |

**Appendix B 7.** Analysis of variance of Lactation Length (LL).

| Source of variation | DF   | Type III SS | Mean Square | F value | Pr. > F |
|---------------------|------|-------------|-------------|---------|---------|
| Genetic group       | 10   | 7853059.479 | 785305.975  | 91.17   | <.0001  |
| Parity              | 9    | 317202.499  | 35244.722   | 4.09    | <.0001  |
| Year group          | 8    | 2960331.433 | 370041.429  | 42.96   | <.0001  |
| Season group        | 2    | 22358.148   | 11179.074   | 1.30    | 0.02733 |
| Error               | 3888 | 2928702.758 | 8613.83     |         |         |

**Appendix B 8.** Analysis of variance of Lactation Milk Yield (LMY).

| Source of variation | DF   | Type III SS  | Mean Square | F value | Pr. > F |
|---------------------|------|--------------|-------------|---------|---------|
| Genetic group       | 10   | 233190.5283  | 23319.05283 | 466.34  | <.0001  |
| Parity              | 9    | 28126.790    | 3125.199    | 6.25    | <.0001  |
| Year group          | 8    | 41661.457    | 5207.682    | 10.41   | <.0001  |
| Season group        | 2    | 3579.905     | 1789.952    | 3.58    | 0.0280  |
| Error               | 4300 | 16996511.930 | 5000.45     |         |         |