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ESTIMATION OF GENETIC AND NON-GENETIC PARAMETERS FOR PRODUCTIVE AND REPRODUCTIVE TRAITS OF CROS- BRED DAIRY CATTLE AT HOLETA AND DEBER ZEITE AGRICULTURAL RESEARCH CENTERES, ETHIOPIA

M.Sc. THESIS

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Estimation of Genetic and non-Genetic Parameters for Productive and Reproductive Traits of Cros- Bred Dairy Cattle at Holeta and Debre Zeit Agricultural Research Centeres, Ethiopia

A Thesis Submitted to School of Graduate Studies, In Partial Fulfilment of The Requirements for the Degree of Master of Science in Animal Sciences (Specialization: In Animal Production)

By

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ADVISORS' APPROVAL SHEET

I hereby certify that I have read and evaluated this thesis entitled "**Estimation of Genetic and Non-Genetic Parameters for Productive and Reproductive Traits of Cross Bred Dairy Cattle at Holeta and Debre-Zeit Agricultural Research Centers Ethiopia"** submitted in partial fulfillment of the requirements for the degree of Master's with specialization in Animal production, the Graduate Program of the Department/School of 'Animal science 'and has been carried out by **Daba Ajema Kitessa** under my supervision. Therefore, I recommend that the Thesis shall be submitted as fulfilled the requirements for the award of a M.Sc. Degree in Animal science.

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As members of the Board of Examiners of the Master of science Thesis open defense examination, we have read and evaluate this thesis prepared by **Daba Ajema Kitessa** and examined the candidate. We hereby certify that, the thesis accepted for fulfilling the requirements for the award of the degree of Master of Science (M.Sc.) in Animal production.

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DEDICATION

This thesis manuscript is dedicated to my beloved families for their inspirations, unreserved, continual prayer and treasuring me with good affection of love throughout my life. So, God bless them.

DECLARATION

By my signature below, I declared and affirm that this thesis is my reliable work. I have followed all ethical principles of scholarship in the preparation, data collection, data analysis and completion of this thesis. All scholarly matter that is included in the thesis has been given recognition through citation. I affirm that I have cited and referenced all sources used in this document. Every serious effort has been made to avoid any plagiarism in the preparation of this thesis.

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BIOGRAPHICAL SKETCH

The author was born on May 1976 in West Showa Zone, Liban Jawe, district, Babiche town. He attended his elementary education at Babiche primary school from 1984 to 1989; he continued his elementary education at Zarf shawl primary school Addis Ababa from 1990 to 1991. He continued his secondary education in Dejazemach Wondered secondary and preparatory school from 1992 to 1993.Then he continued his secondary education in Kombolcha secondary and preparatory school from 1994 to 1995. Then he joined Kombolcha Agriculture training centre and awarded certificate and he employed in Oromo especial Zone Bati District agriculture and rural development office as development agent after four years of service in the office, he joined Alage Agricultural College and awarded a Diploma in Animal Science in 2005. After graduation, he turned back to Bati District agriculture and rural development office and service as supervisor, then after one years of service in the office, he has joined Bahir Dar University to pursue his BSc degree and awarded with BSc in animal production and technology in 2012. Then after, the author returned and continued his work in Bati District agricultural office as animal production expert. In 2015, he left the district Agriculture office and then joined Ministry of Agriculture and has worked as dairy expert until he joined the postgraduate program directorate of Wolkite University in 2020 to pursue his M.Sc. study in Animal production.

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LIST OF ABBREVIATIONS AND ACKRONYMS

AFC	Age at First Calving
AFS	Age at First Service
AI	Artificial Insemination
ALPPIS	Addis Livestock Production and Productivity Improvement Service
AM	Ante-Meridian
ARC	Agricultural Research Center
BLUP	Best Linear Unbiased Predictions
CBPP	Contagious Bovine Pleuropneumonia
CI	Calving Interval
CSA	Central Statistical Agency
DMY	Daily Milk Yield
DZARC	Debre-Zeit Agricultural Research Centres
EATA	Ethiopian Agricultural Transformation Agency
EIAR.	Ethiopian Institute of Agricultural Research
FAO	Food and Agriculture Organization of the United Nations
FMD	Foot and Mouth Disease,
GDP	Gross Domestic Product
H A R C	Holeta Agricultural Research Canters
H^2	Heritability
HF	Holstein Friesian
I GAD	Inter-Governmental Authority on Development
ID	Identification
LDI	Livestock Development Institute
LL	Lactation Length;
LMY	Lactation Milk Yield
MASL	Metres Above Sea Level
MOA	Minister of Agriculture

NAGII	National Animal Genetic Improvement Institute
NGO	Non-Governmental Organization
NSC	Number of Services Per Conception
PM	Post Meridian
SE	Standard Error
UNRRA	United Nation Relief and Rehabilitation Administration
WHO	World Health Organization
WWS	Worldwide Sire

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ABSTRACTS

The comparative estimation of genetic and non-genetic parameters of productive and reproductive traits of local and cross-bred dairy cattle conducted at Holeta and Debre Zeit Agricultural research Centers based on long-time recorded data generated for the last 46 and 33 consecutive years was used for this study. The average lactation milk yields of dairy cattle in both research centers were 14 24.32 ± 41.56 for local, 2334.08 ± 28.63 for 50%, 2354.08 ± 28.63 for 50% -75% and 2108.32 ± 41.56 (L) for >75%. The mean average of lactation milk yield (LMY) for all cross bred was 2265.49±32.94 (L) whereas the average LMY for locals was 1424.32 ± 41.56 (L). Lactation milk yields of cross-bred dairy cows with different exotic blood level in both research centeres were highly significant ($P < 0.001$). Genotype, calving years, location of the centers, calving season and parity were significant ($P < 0.05$). The average lactation length (LL) of dairy cattle in both research centeres were 204.43 ± 2.60 for local, 285.06 ± 2.32 for 50%, 282.5 ± 2.32 for 50-75%, and 273.04 ± 2.19 days for >75%, and the mean average lactation length (LL) was 280.2±2.28 days for cross bred and 204.43± 2.60 days for locals. Cross-bred dairy cows with different exotic blood level (local, 50%, 50% -75%, and >75%) in both research centres were highly significant ($P < 0.001$). The average calving interval(CI) of dairy cattle in both research centers was 478.31 ± 7.69 for local, 472.85 ± 5.88b for 50%, 482.75 ± 5.85 for 50% -75%, and 503.56 ± 5.77 days for >75% with the mean average calving interval of 486.39±5.83 days for crossbred dairy cattle. Calving interval (CI) of cross-bred dairy cows with different exotic blood levels (local, 50%, 50-75% and >75%) in both research centres were highly significant ($P < 0.001$). Age at first calving (AFC) were 1171.62+39.40, 1103.49+ 29.42, and 1184.28+29.56 days for local, 50%, 50-75% and >75%), respectively with a coefficient of variation 17.31% in both research centres. AFC is not significant ($P>0.05$) between the two research centers. The average days open and number of services per conception of dairy cattle in both research centres were 268±58.9 and 2.18±45.9 for locals, 195±35.7 and 1.45±35.6 for 50%, 185±43.3 and 1.25±55.4 for 50%-75%, and 165±38.7 and 1.22±45.4 for >75%, respectively. The variance of analyzed factors such as centres, calving year and calving season were not significant ($P>0.05$) in number of services per conception. Location of the centres and calving year were significant ($P < 0.05$) in number of days open. Parity and calving season were not significant ($P>0.05$) in number of days open. Parity was significant ($P<0.01$) in number of services per conception while genotype was highly significant ($P<0.001$) in days open and number of services per conception. Direct heritability *ranged from 0.043 in calving interval to 0.393 in age at first calving for the dairy herd maintained at Holeta agricultural research center. The phenotypic correlation among the pairs of traits investigated ranged from 0.022 in lactation length and age at first calving to 0.931 in total milk yield and lactation length. The repeatability values for the traits analyzed ranged from 0.133 in calving interval to 0.244 in total milk yield for the dairy herd maintained at Debre Zeit Agricultural Research Center. In general, the increasing and decreasing genetic trends over the observed year and seasons show that making the right decision for the right selection of breeds and culling unproductive breed which leads to dairy cattle production and reproductive performance improvement through good farm management conditions in the right environmental conditions.*

Keywords*; Holeta, Debre-Zeit, genetic performance, production, reproduction trait*

1. INTRODUCTION

1.1. Back ground

Ethiopia stands home-based for many livestock species and appropriate for livestock production, possessing the largest livestock population in Africa (Tadesse et al., 2014). According to the report of the Central Statistical Agency, the cattle population was estimated at about 70 million in the country (CSA, 2021). From the total population, indigenous breeds accounted for about 97.4%, while the hybrids and pure exotic breeds were represented by about 2.3% and 0.31%, respectively. From the cattle population of 56%, females, this indicated that dairy production in Ethiopia is mainly based on indigenous breeds of dairy cattle which have low productivities and reproductive performance (Shiferaw et al., 2003; Kumar and Tkui, 2014; CSA 2021).

Even-if local breed dairy cattle productivities and reproductive performance is low, livestock production plays indispensable role for the national economic growth, job creation, human healthiness as well as increased food security and poverty mitigation in Ethiopia (Azage *et al.*, 2010). The cattle production gives multi-purpose role which provide milk, meat, fertilizer, fuel, draft power and also as a means of economic increase from the sale of milk and milk products (Desalegn *et al.*,2016). The methods of livestock production and productivities must change to allow for efficiency and improvement in productivity, was Cross breeding of native and improved dairy cattle breeds proposed as one of the options as genetic improvement strategy in tropics, (Tadesse, 2002; Geberyohanes *et al.*,2013; Mebratu *et al*., 2020).

Similarly, in Ethiopia, cross-breeding has been practiced since Ethiopia received the first batch of exotic breeds from the United Nations Relief and Rehabilitation Administration (UNRRA) (Aynalem, 2006). Cross-bred dairy cattle are one of the top milk producing breeds of cattle in Ethiopia (Addisu et al., 2010). Selection for milk production traits leads to deterioration in reproductive traits due to their antagonistic genetic correlations. Multi-trait evaluations of reproductive traits with production consider the covariance between traits and this helps simultaneous improvement of production and reproduction traits (Wondossen et al., 2017).

Genetic parameters are population specific which have not a biological constant (change over time) due to management decision, migration of genes from one population to another, as well as environmental variability, on-going selection and use of different sires to create genetic variation in the farm (Chikosi, 2010; Gebregziabher, *et al*., 2013). While different estimation of genetic parameters may be found for the same trait in different populations or in one population at different times, (Demeke *et al*., 2004).

Estimation of genetic parameters is a prerequisite for successful dairy development and essential for various livestock traits and has been a main subject of animal breeding throughout the past half century. A lot of research has been conducted to estimate the reproductive and productive performance of cross-bred centers, especially for different exotic blood levels cross-bred of dairy cows under a comparatively controlled condition at research centrers (Selam et al., 2015). Further, more, genetic evaluation on cross-bred cattle in Ethiopia mainly focused only on improving milk production (Ayenalem et al., 2010; Geberyohanesm et al., 2013).

1.1. Statement of the Problems

Different research work was done on different government and private dairy farms at different times by several researchers & scholars, to estimate genetic parameters of productive and reproductive performances of local breeds, Holstein Friesian and their crosses in Ethiopia (Million, and Tadele, 2003; Yosef, et al., 2003; Kefena, et al., 2006; Gebyehu, et al., 2007; Amene, et al., 2010; million, et al., 2010). Cattle, productive traits are repeated over time. Repeated measurements of the same trait can be likely to compute the repeatability estimate, which is the fraction of variance and (co) variance, which was due to the permanent difference between individuals.

In dairy cattle, repeatability as well as non-repeatability estimations show the strength of the association or correlation between the repeated and none-repeated records for a trait in a population, and this may be assessed by the real productivity and reproductive competence of individual cows in a population (Olawumi and Salako, 2010). While there is a lot of work done by scholars & researchers, there are still information gaps in the estimation of genetic performance of the productive and reproductive potential of cross-bred dairy cattle at different dairy farms in Ethiopia, because of lack of organized animal data at the national level (Demeke et al., 2004).

These forced them to use data obtained from small herd sizes (small record data) for the studies, which might distort the estimation of genetic parameters. Therefore, here it is essential repeated estimation of genetics parameters of Local and cross-bred dairy cattle productive and reproductive performance, at Holeta and Debre Zeit agriculture research center dairy farms of Ethiopia, in which different blood level dairy breeds are maintained at different location of the country. The Borana pure breed is used as a mother base; HF x Borana is maintained in both centers. HARC up to 75% blood level, kept developing breeds and DZARC, kept pure local breeds and cross-breeds to develop from 50% up to 99.60% blood level.

Most performance evaluations of productive and reproductive traits of dairy cattle in Ethiopia were based on a single trait analysis. Evaluation based on single trait analysis does not account for the covariance among traits and this leads to selection bias and inaccurate breeding value estimates (Unalan and Cibeci, 2004; Wondossen et al., 2017).

So, it needs to be estimated by including large and updated data for perfect selection and accurate estimation of breeding value. Through multi-trait evaluations of reproductive traits with production, consider the covariance among traits and this aids simultaneous improvement of production and reproduction traits (Wondossen et al., 2017). Thus, studies have been generating baseline information mainly for livestock owners, extension workers, researchers and policymakers for genetic performance improvement. Therefore, this study was designed to use the Wombat genetic analysis model with the following objectives.

1.1.1. Objective

1.1.2. General objective

To Estimating genetic and non-genetic parameters of productive and reproductive traits of local and cross-bred dairy cattle populations at Holeta and Debre-Zeit agriculture research centres.

1.1.3. Specific Objectives

- To determine genetic and non-genetic effects on reproductive and productive traits of local and cross-bred cattle at Holeta Agricultural Research center and Deber Zeit Agricultural Research centres.
- To estimate genetic parameters for productive and reproductive traits of local and cross-bred dairy cattle at Holeta Agricultural Research center and Deber Zeit Agricultural Research centers.

1.1.4. Research Questions

1. What are the major factors that affect milk production and reproduction potential of the Crossbred dairy cattle in the Holeta and Debre Zeit agriculture research center?
2. Which genetic variability affects dairy cattle's productive and reproductive traits in Holeta and Debre Zeit agriculture research center?
3. How do non-genetic factors affect the production and reproductive potential of dairy cattle in both research centers?

1.1.5. The scope of this research

This research work was conducted at Holeta and Debre Zeit Agriculture research centers, where local pure breed and Borana X HF crossbred dairy cattle are maintained for the purpose of research and dairy farm development.

2. LITERATURE REVIEW

2.1. Milk production traits of pure Borana breed dairy cattle and Holstein Friesian crosses with Borana dairy breed in the tropics

2.1.1. Dairy cattle cross-breeding in Ethiopia

Genetic improvement of dairy cattle works primarily aimed at improving the economic performance of milk production. These improvements were achieved by selecting the animals which would be more profitable than their parents. The Holstein Friesian is the dominant dairy cattle breed in many countries, including Ethiopia, which a reflection of the high level of efficiency of the breed for milk production. Selection for milk production efficiency within the Holstein Friesian breed has led to a decline in functional traits, including fertility, and has prompted a renewed interest in cross-breeding (Banga, 2009).

Dairy production in Ethiopia was mainly based on native breeds of cattle and breed development and expansion programs have been focussed mostly on crossbreeding activities through research stations. Therefore, crosse breeding is combining the genetic adaptability to the harsh conditions, disease and heat tolerance, the ability to utilize poor quality feeds of local cattle through the high milk production potential and earlier growth rates of exotic cattle breeds, through cross-breeding by exploitation of heterosis in the first generation leading to good adaptability, upsurge fertility, decrease mortality, appropriate growth rate, feed adaptation and particularly for increase of milk production, has been practice as a more maintainable method to improve productivity. Cross-bred has been a progeny crossing of any two cattle breeds to produce an animal midway between the two parents and with the advantages of both (Kefena et al., 2011).

Cross-breeding has long been in a condition as an applied response in Ethiopia for decades to carry about the wanted genetic change rapidly to combine the high efficiency of exotic and better adaptability of indigenous breeds to existing weather conditions, disease, low quality feed and lead long period dairy cattle cross-breeding, work in Ethiopia has been initiated in the early 1950s when Ethiopia received the first batch of exotic (Friesian and Brown Swiss) dairy cattle from the United Nation Relief and Rehabilitation Administration (UNRRA), cross-breeding has been started by the Institute of Agricultural Research, through the establishment of an on-station. The Cattle Cross-breeding Program, using Friesian, Jersey and Simmental sires that were crossed with the indigenous breeds like Horro, Borana and Barka dams with the aim of testing the productivity and reproduction of cross-bred dairy cows with different exotic blood levels (Aynalem, 2006).

Cross-breeding of indigenous cattle breeds with Holstein Friesian cattle breeds has been extensively used as an instrument to make milk production possible in tropical cattle (Raden et al., 2003; Belay et al., 2016). Although native cattle breeds are well adapted to local production conditions, they usually mature late and have poor growth rates and low milk yields (Gebayehu and Singh, 2005; Galukande et al., 2013; Gebrehiwet, 2020).

The Borana breed is one of the tropical native breeds and groups of large east African Zebu cattle that were broadly spread across several countries in Africa. The breed, which has a high degree of heat and disease resistance usual in the tropics and the capacity to endure the long periods of feed and water scarcity, and is talented and well adapted to semiarid tropical conditions, is categorised as an improved and unimproved type. The unimproved Borana is used in subsistence and semi commercial systems of production in Ethiopia, Kenya, and Somalia (Aynalem *et al*., 2011). The Borana breed has been used as one of the preferred dam breeds in dairy cattle crossbreeding and genetic improvement studies in Ethiopia over the last six decades. Their crossbred has been found to be fast growing, fertile, and a good milk producer compared to other indigenous breeds in Ethiopia. The genetic variances, heritability, and repeatability estimates of pure Borana and their crosses are important aspects of the crossbreeding as well as the pure breeding programme in the country (Haile *et al*., 2009).

The development of breeding goals and essential genetic improvement programmes requires knowledge of the genetic variation among economically important traits and accurate estimates of heritability, repeatability, and genetic correlations of economically important traits. Repeated hereditary and ecological effects are recognised as disturbing the reproductive and productive performance of cross-bred dairy cows. The cross-bred dairy cattle have confirmed their best possible performance in appropriate climatic conditions and genetic production potential, attaining the required level of reproduction performance. The achievement of dairy production and reproductivities performance over all through cross-breeding data bases, which needs specific monitoring frequently through evaluating the productivities and reproductivities potential in the present ecological conditions and management scheme (Shiferaw *et al.*, 2003; Juma and Lakas's, 2006).

The ideal breeding method and lifetime production in herds are dependent on an oestrus detection system, the proper time of insemination, proper feeding, and health care practices (Berihulay and Mekasha, 2016). The most likely management factors that accounted for the longer period of AFC, CI, and DO were poor efficiency of oestrus detection and expression (Worku et al., 2016). Dairy cattle performance was influenced by breed, nutrition, diseases, breeding, and management practices. Cross-breeding of local breeds with exotic dairy breeds has been widely used as a tool to improve the milk production potential of dairy in tropical regions (Duguma, 2021).

As part of the same effort, cross-breeding has long been a practical solution in Ethiopia for decades to bring about the desired genetic change quickly to combine the high productivity of exotic and better adaptability of indigenous breeds to existing climate conditions, diseases, low-quality feed, and poor management in cross-breeds. The Ethiopian Institute of Agricultural Research has conducted long-term dairy cattle cross-breeding experiments in some research centres in the country.

Holeta and Debre Zeit Agricultural Research Centers were the main research canters which have been playing a great role in improvement of dairy cattle in the country. In these research centers, Boran/indigenous cattle have mainly been crossed with Holstein-Friesian with the aim of combining productivity and adaptability in the crossbreds. This long-term crossbreeding effort resulted in the development of various genetic groups which could be vital to analyze the data and suggest possible intervention for improving the breeding program in the futures (Tadesse, *et al*., 2015).

2.1.2. Milk production traits of local and its crossbreed dairy cattle

The majority of indigenous tropical breeds of dairy cattle are low producers of milk with high individual erraticism, which is credited to natural selection of the tropical environment and management. To increase their production performance, the introduction of high-produced breeds (Holstein-Friesian, Jersey, and Simmental) has been playing an important role. But, the potential of these breeds is frequently affected because of genetic constitution and environmental interactions. Cross-breeding of tropical native breeds with temperate dairy breeds has been used in different countries as a means of increasing milk production and total selection indexes have been initially, emphasized on milk production traits (Gebregziabher et al., 2014).

Dairy production in the livestock production system is a critical issue in Ethiopia, where livestock and its products are more important sources of food and income, while dairying has not been fully exploited and promoted in the country due to different reasons, which imposed the dairy subsector low in production and reproduction performance in general, and compared to its potential, the direct contribution which it makes to the national economy as well as the per capita/person/year milk consumption in the country (Dash et al., 2016). Dairy production is one of the main sustenance powers for the economy of Ethiopia. Ethiopia has a huge potential for dairy development because of its huge livestock population. The dairy sector can contribute significantly to poverty mitigation and nutrition in the country. Genetic improvement of dairy cattle will be primarily aimed at improving the economic efficiency of milk production. Such improvement is achieved by selecting animals that will be more profitable than their parents.

Milk production of cross-breeds is thought to be higher than that of local zebu, as well as that they have better reproductive and production performance such as; short (age at first calving, days open, calving interval and number of services per conception (Banga et al., 2009; Galukande et al., 2013; Gebregziabher et al., 2013; Getabalew et al., 2019). The productive performance of dairy cattle is regularly measured by the total milk produced per lactation or per year. Reproductive failure has a clear negative influence on milk production and farm income and determines the future sustainability of a dairy farming process. Milk production is affected by genetic and environmental factors. Among the environmental factors, the quantity and quality of available feed resources are the major ones. Profitability of a dairy initiative depends on gaining as high a level of milk production as possible with accessible feed, relative to the maintenance cost of the animals. Systematic decline in daily milk yield gives a warning of disturbances in milk production, which can be used as a tool for early warning, management decisions and predicting production capacity. Predicting daily yields from one milking cow milked twice a day must also take into consideration that morning milk yields are a more constant proportion of total daily yields than evening milk yields. In modern dairy farms, a lactation length of 305 days is commonly accepted as a standard (Zewudu et al., 2013). But such a standard lactation length might not work for smallholder dairy farms in which the lactation length is extended- significantly in most cases, the profitability of short or extended lactation length depends on various factors including the lactation length persistency. In the tropics, dairy farming based on indigenous cattle alone, would not be a quick and suitable option to meet the increasing demand for milk and milk products (Kefyalew and Damtie, 2015).

The most favoured alternative so far has been crossbreeding and most crossbreeding improvements in the tropics have therefore been sought to boost the milk breed productivity of indigenous cattle breeds and there have been persistent attempts to cross-indigenous cattle breeds with imported dairy breed, productive performance of cross-breed dairy cattle was not achieved more than 7 liters of daily milk yields and 2500 liters of lactation milk yield with any one of the genetic group at on station condition even cross were milked more than standard lactation period, however, recent reports indicated that more than 9 liters of milk yield were obtained from cross-bred dairy cows at on farm level (Mebrahtom and Haile Michael, 2016).

F1 Barça dairy cattle had a higher daily milk yield than f1 Borana dairy cattle cows and this superiority tended to be repeated in 75% and 87.5% crosses with Holstein, this superiority of 50% (f1) over 75% (f1) crosses 6 litrs and 5.7 liters respectively for daily milk yield, on the other hand the consistent of increase in milk yield with increasing the level of exotic genes from 50% to 100% (Kefena etal.2006a). However, productive performances radically dropped in F2 cross performance, though the proportion of exotic genes is similar to that of F1 cross levels, as exotic blood levels increased, reductions in their milk yield performance were observed (Addisu, 2013; kefayalew and Damtie, 2015). The value of productive performance of crossbred dairy cattle is different in different parts of Ethiopia (Sisay, 2015). There were found a mean value of lactation milk yield of 1768.15 ± 15.28 and 1293.01 ± 23.70 from Horro x HF and Horro x Jersey genetic groups, respectively, at Bako (Belay et al. 2012).

In Jimma town, the performance of zebu and Holstein Friesian crossbred dairy cows was 701 ±2.73, 5.55 ± 2.83 and 3.50 ± 1.64 liters per cow, for first, second and third parties, respectively (Kefyalew and Damtie 2015). Around Gondar, an average daily milk yield of 6.27 and 6.90 kg and 6.95 and 6.46 kg, around Bahir Dar, from 50% and 75% exotic blood levels, other researches in North West Ethiopia, obtained 7.3 ± 3 and 8.8 ± 2 kg of DMY with 310.9 ± 42 and 303.4 ± 46 days of lactation length from 50% and 75% crossbred (Melku et al. 2017). Beyond the level of feeding management, a variety of non-genetic factors (season, year and parity) influenced productive performance of dairy cows; lactation milk yield and lactation length were significantly influenced by season and parity (Belay et al., 2012)

In India, maximum and minimum production of milk was obtained during the winter (December to February) and summer (March to May) seasons, respectively (Zewudu et al. 2013). The influence of parity on LMY and LL was significant and reflected a progressive trend from first parity to fourth on lactation milk yield. In addition to this, lactation milk yield, daily milk yield and lactation length were significantly affected by the year of calving (Kefena et al. 2011; Zewudu et al., 2013; Kumar et al., 2014; and Yohannes et al. 2016). In general, milk traits of dairy cows are repeated over time. With repeated measurements of the same trait, it can be possible to calculate the repeatability estimate, which in fact is the fraction of variance that is due to permanent difference between individuals. In dairy cattle, the measure of repeatability estimate refers to strength of the relationship or correlation between repeated records for a trait in a population and this may be utilized to assess the real producing ability of individual cows in a population (Olawumi and Salako, 2010). In dairy farms, production and reproduction improvement is important because it boosts milk production output by lowering dairy cattle elimination rates and increasing breeding success rates (Lu et al. 2021). Milk production, herd replacement, and general profitability were consequently serious components of reproduction in dairy farming (Getahun et al., 2019).

Table 1.Milk production performance of local and cross bred dairy cattle in Ethiopia

Breed (Genotype)	Productive trait performance				Sources
	DMY (L)	LMY (L)	LL (days)	Study areas	
Holstein Friesian (H)	9.8	3311	335	On station	(Demeke et al., 2004)
F1 (H x B)	6.2	2278	374	On station	
F2 (HB x HB)	5.6	1947	348	On station	
B1 (5/8H3/8B)	6.3	2194	339	On station	
B2 (3/4H1/4B)	6.9	2312	348	On station	
50%HF x Borena	6.4	2031	337		(Gebregziabhere et al. 2013)
75%HF x Borena	7.02	2240	343		
50%Jersey x Borena	5.6	1788	315		
75%Jersey x Borena	5.7	1833	303		
50%HF x Horro	5.7	1836	321		
Friesian x Borena	6.8	2184	361		
Jersey x Borena	5.9	1622	304		

DMY= daily milk yield, LMY= lactation milk yield, LL= lactation length

2.1.3. Milk production traits of crossbreed dairy cattle

It is the amount of milk that a cow produces in one lactation period. It is affected by the daily milk yield and lactation length. Increasing lactation milk yield is important for farmers to increase the profitability of their cows. It was reported that the range of average LMY of Holstein Friesian crosses with a local breed is from 2772.76 kg to 3710 kg (Sattar et al., 2005; Abdullah 2005; million et al., 2010; Usmane et al., 2012). The milk production performance of dairy cattle is usually measured by determining the total milk yield per lactation or per year, average daily milk, yield, lactation length, lactation persistency and milk composition (Galukande et al.,2013; Gebregziabher et al., 2013; Getabalew et al., 2019).

Lactation yields of the first and third lactation for Arsi Zebu cows varied from 224 to 491 kg (Haile et al., 2011). Which shows that the 50% Holstein Friesian cross has a quadruple increase over the Ethiopian local dairy breed in terms of lactation milk yield, 305-days milk yield, daily milk yield and lifetime milk yield. They were also milked for 97% more days than Ethiopian Boran (Ahmed et al., 2007). In Sudan, lactation milk yield increased significantly with the rise in Bos-taurus blood up to 50%, and then there was no significant change as foreign blood rose to 87.5% (Gebayehu and Singh, 2005). Lactation milk yield increased significantly with the rise in Bos-taurus blood up to 50%, and then there was no significant change as foreign blood rose to 87.5% (Gebayehu and Singh, 2005).

2.1.4. Lactation length (LL) of crossbred dairy cattle

Lactation length refers to the time of period from when a cow starts to secrete milk after parturition to the time of drying off. A lactation period of 305 days is recommended to take advantage of 60 days of dry period. Lactation length of indigenous cattle increased in correspondence with exotic blood levels because of the combination of both genetics. The average lactation length of indigenous Arsi, Zebu and Boran breeds was 203.75 days while the average lactation length of their 50%, 75% and 87.5%, crosses were 262.25, 284.25, and 294.25 days respectively. Similarly, another study conducted in the North Showa zone indicated that local breeds (273.9 days) had shorter lactation length than cross-breeds, 333.9 days (Mulugeta and Belayneh, 2013).

The estimated lactation length was comparable to the ideal lactation length of 305 days (Foley et al., 1972). Even though there was an incremental trend in lactation length as blood levels increased, they could not reach the generally accepted 305 days of lactation length for crossbreeds. This might be due to the reasons of poor nutritional status, poor breeding management, diseases and poor management practices. Another author also supports this idea, in which the level of management achievable in Ethiopia is unfavourable to higher exotic inheritance levels than 50% Holstein Friesian inheritance. The F1 cross had the shortest lactation length compared to other crosses. They reported that lactation length of 272 and 303 days for Arsi and Zebu breeds in Ethiopia, respectively, lactation length decreased slightly with increasing lactation number (Aynalem et al., 2009; Belay et al., 2012).

Lactation length of crossbred of different indigenous cows with Holstein Frisian/HF with different exotic blood level of Ari X HF of 50%, 75% and 87.5% have lactation length of 334,408 and 411 days respectively and crossbred of Zebu X HF of 50%, 75% and 87.5% have lactation length of 378, 378 and 411 days respectively, as well as crossbred of Borana X HF of 50%, 75% and 87.5% have lactation length of 337, 351 and 355 days respectively (Aynalem et al., 2011). Milk production per lactation of crossbred of different indigenous cows with Holstein Frisian/HF with different exotic blood, level of Ari X HF of 50%, 75%

and 87.5%, have, milk yield of 1741, 2374 and 2318 Liters respectively, and, crossbred of Zebu X HF of 50%, 75% and 87.5% have milk yield of 2352, 2356 and 2318L respectively, as well as crossbred of Borana X HF of 50%, 75% and 87.5% have lactation milk yield of 1740, 2044 and 1902 L respectively, as exotic blood level is increased all reproductive and productive trait performance of crossbred were increased until 75% exotic blood level, and then it shows turn down (Million and Tadelle, 2003).

Table 2. Lactation of milk yield and lactation length

Breed	Productive trait performance			Source
(genotype)	Country	LMY (L)	LL (d)	
Friesian cows	Sudan	3475	294	Abdel et al. (2007)
Imported Friesian	Sudan	5468	332	Amasaib et al. (2008)
Locally born Friesian	Sudan	4222	321	Amasaib et al. (2008)
50% Friesian blood	Sudan	2645	402	Amasaib et al. (2008)
56.5% Friesian blood	Sudan	2052	375	Amasaib et al. (2008)
62.5 Friesian blood	Sudan	2564	376	Amasaib et al. (2008)
Holstein-Friesian Cattle	Pakistan	3977	314	Sandhu et al. (2011)
Holstein-Friesian cross	Ethiopia	2314	274	Belay et al. (2012)
Tunisian Holstein cows	Tunisia	5807	309	M'hamdi et al. (2012)
Holstein Friesian	Pakistan	3438	366	Usman et al. (2012)
Brown Swiss	México	3564	348	Utrera et al. (2013)
Holstein cows	México	3825	358	Utrera et al. (2013)
Indigenous cow	Ethiopia	403	204	Niraj et al. (2014)
Holstein Friesian cross	Ethiopia	2123	325	Niraj et al. (2014)

LMY=lactation of milk yield, LL=lactation length

2.2. Reproductive Traits of indigenous & cross bred dairy cattle

The final goal of the dairy industry is efficient production, which is influenced by the reproductive efficiency of the dairy cattle, which indicates the importance of measuring reproductive performance in cows. It is of economic benefit to the producer for a cow to produce a calf every year. The most common indices of reproductive performance are age at first calving (AFC), calving interval (CI), days open (DO), number of services per conception, (NSC), breeding efficiency, calf crop and other fertility traits (Kefena et al., 2006); (Hammoud et al., 2010). The reproductive performance of the breeding female is probably the most important factor. It is a prerequisite for a sustainable dairy production system and influences herd productivity in all forms of output; milk, meat, traction, fuel, as well as provision replacement of animals. Reproductive performance is influenced by feeding, genetics, and diseases and a huge variety of management practices. Reproductive performance is one of the major factors other than milk production that affect productivity and profitability of a dairy herd affects reproductive performance, and it is a biologically crucial phenomenon which determines the efficiency of animal production. The production of milk and reproductive stock is not possible unless the cow reproduces. Poor reproductive performance is caused by failure of the cow to become pregnant primarily due to anoestrus (postpartum or pre-pubertal), failure of the cow to maintain the pregnancy, and calf losses, which cause delays in age at first calving and a long calving interval (Megersa, 2016). Reproductive performance of cross-bred cows was better and lower due to late AFC, long CI, shorter LL, low daily and LMY, and high NSC. On the other hand, management in consistency and variability of climatic variables across year and season appear to have a significant influence on cow reproductive efficiency (Hammoud *et al*. 2010; Beneberu *et al.*, 2021;). The sire of the cow, management system, and appropriate environmental conditions all has a significant influence on the reproductive efficiency of Friesian cows in semiarid Egypt. Improvement in management and parent selection based on breeding value would improve the reproductive performance of dairy cattle (Beneberu et al. 2021).

In Ethiopia, reproductive efficiency of both indigenous and crossbred cow selection, environmental variability, and the use of multiple sires all contribute to the farm's genetic diversity (Getahun *et al.* 2019; Beneberu *et al.* 2021). Comprehensive and up- to-date information on the breeds' performance in terms of reproduction, improvement, and milk yields, as well as the factors influencing those performances, is critical for long-term breed improvement and conservation efforts (Bayou et al., 2015).

As a result, regular evaluation of dairy cow productivities potential at the research centers was serious for the future breeding program (Getahun et al. 2019). According to many researchers, Horro and its crosses with Holstein Friesian and Jersey dairy cows have significant reproductive success (Gebregziabher et al. 2005; Kebede et al. 2011). 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 reproductive work of a dairy herd. The production of milk and reproductive stock is not possible unless the cow reproduces. Reproductive performance is designed as the number of cows that get pregnant divided by the number of cows that are eligible to get pregnant. Reproductive performance is commonly assessed by analyzing female reproductive traits.

The key indicators that would be considered in evaluating reproductive performance are age at first service, age at first calving, calving interval, days open and number of services per conception (Habtamu et al., 2010; Aynalem et al., 2011; Demissu et al., 2013; Megersa, 2016; Mebratu et al., 2020). Reproduction is the backbone of animal production and productivity is the major component to growth of dairy cattle genetics. Reproductive inefficiency is one of the main dominant reasons for economic losses in animal production, and it is realized throughout the world. Despite the remarkable progression that has been made in the field of reproductive physiology in existing periods, infertility because of low conception rate and extreme embryonic death rate remains a main problem (Verma et al., 2012).

To meet future needs and to be able to withstand animal agricultural production, agricultural research and its applications need to use all developing technologies, one of which is modern reproductive biotechnologies. Thus, various assisted-reproductive techniques have been developed and refined to obtain numerous offspring from genetically superior animals or obtain offspring from infertile (or sub fertile) animals in addition to disease control (Mapletoft, 2018; Hadgu and Fesseha 2020). The reproductive performance of the breeding female is probably the single most important factor that is a prerequisite for sustainable dairy production system and influences productivity. In particular, the economics of a dairy enterprise is based on the efficient reproductive performance of dairy animals. Productive performance is a physically crucial phenomenon that determines the efficiency of animal production.

The production of milk and reproductive stock is not possible unless the cow reproduces. Poor reproductive performance is triggered by failure of the cow to become pregnant mainly because of anestrus (pre-pubertal or post-partum), failure of the cow to maintain the pregnancy, and calf fatalities. This causes delays in age at first calving and long calving intervals (Aynalem et al., 2011; Gemeda, 2021). Maximum rates of breeding efficiency in dairy cattle are attained through regular calving of one viable offspring per breeding cow in the herd in a year. Lowered breeding efficiency rates can be due to the long calving interval of a dairy cow, which is mainly due either to low conception rate or high early embryonic death. Poor reproductive performance results in an excessively late age at first calving and long lactations. Both are costly to the dairy producers because of the veterinarian breeding expense, high reproductive replacement costs, and fewer calves being born (Hammoud et al., 2010).

Low reproductive efficiency due either to delayed first service, missed oestrus or multiple services per-conception continues to be a major problem in dairy herds. Several reports have indicated that poor reproductive performance, manifested as prolonged calving intervals, can result in reduced milk yield and increased culling rates and replacement costs. Such animals are not suitable for the application of reproductive biotechnology (Sewalem et al., 2008). Reproductive biotechnologies are intended to be used routinely to shorten generational intervals and to propagate genetic material among breeding animal populations. To achieve this goal, reproductive technologies have been developed in generations over the years, namely artificial insemination (AI), using hormone synchronization technology, embryo transfer ET (Morrell et al., 2011; Hadgu et al., 2020). These techniques together all face today a strong wave of increasing dairy production and commercialization (Seidel, 2008).

Table 3. Reproductive performance of local, crossbreed and exotic cattle in Ethiopia

Breed	Reproductive trait performance				Sources
	AFC (month)	CI (days)	NSPC	Location	
Borana breed	42.5	473	1.71	station	(Demeke et al., 2004)
Holstein, Friesian	37.3	459	1.73	station	
F1 (H x B)	36.0	417	1.49	station	
F2 (HB x HB)	39.6	435	1.60	station	
B1 (5/8H3/8B)	38.5	426	1.41	station	
B2 (3/4H1/4B)	36.7	444	1.70	station	
highland zebu	46.1	576	1.74	On-farm	(Getinet, et al. 2009)
Ogaden breed	16.4	1509.6	2	station	

AFC= age at first calving, CI= calving interval, NSPC= number of services per conception 50.3 2.

2.2.1. Age at first calving (AFC)

The beginning of a productive life for the heifer is called age at first calving. First, calving characterizes the start of the productive life of a cow by having an influence on both the reproductive and productive life of the dairy cattle, directly having an effect on her lifetime calf crop and milk production, and indirectly through its influence on the cost that has been invested in the upbringing (Tewodros 2008; Azage et al., 2011; Megersa, 2016). 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's productive and reproductive life, both directly and indirectly, through its consequences on her generation calf crop and milk production, as well as the cost of rearing (Hammoud et al., 2010; Gebrekidan et al., 2012; Megersa, 2016).

Under a controlled breeding system, heifers are usually mated when they are mature enough to withstand the stress of parturition and lactation. It is recommended that heifers calve between 23 and 25 months of age, which is considered as optimum to increase the profitability of the dairy business (Hammoud et al., 2010). In regard to genotype differences, the most profitable age at first calving may differ to some degree between breeds and the study reveals that the most profitable first calving age for Holstein and Jersey is 22 months, whereas for Ayrshire and Brown Swiss, it is 23 months (Beaverly, 2015).

In Ethiopia, research work has been done with different genetic groups both on station and on farm, which have been focused on crossbred reproductive performance of dairy cows and reported F1 Jersey crosses had 2.85 months shorter AFC than F1 Friesian crosses and F2 Jersey crosses had 4.49 months shorter AFC as compared to their F2 Friesian counterparts (Kefena et al. 2006a). However, there is no difference observed in AFC between crosses with 75% exotic inheritances, the values of 39 ± 0.6, 41 ± 01, 40 ± 0.9 and 39 ± 1.3 for 50%, 62.5%, 75% and 87.5% crosses of Holstein and Borana, respectively (Haile et al. 2009b).

The values for age at first calving of crossbred dairy cattle is different in different areas depending are on crossbred type, exotic blood level and production system (Solomon et al. 2009). Other researchers found that the crossbred cows performed higher AFC (52 ± 2.5 months) under a smallholder management system. In addition to this, the values of 39.6 ± 0.40 months, 34.8 ± 0.21 months, 35.87 ± 0.10 months, and 40.88 ± 5.51 months, (Aregawi, 2013; Alemshet, 2014; Megerssa 2016; Melku, 2016). Friesian × Borana crosses had significantly shorter (P<0.05) AFC than Friesian × Arsi crosses, with an estimated overall mean value of 39.49 ± 0.83 months for Friesian × Borana and 42.84 ± 0.84 moths for Friesian × Arsi.

Table 4. Age at first calving (AFC), calving interval (CI) and Days open (DO) for different breeds of dairy cows in Ethiopia

Breeds (Genotype)	Reproductive trait performance			
	AFC (months)	CI (Days)	DO (Days)	source
HF	42.13 ± 0.70	413.04 ± 7.31	139.58 ± 7.91	(Mengistu *et al.* 2016)
HF	42.13±0.70	413.04±7.31	139.58±7.91	(Mengistu *et al.* 2016)
Jersey	29.92 ±0.17	497.08±3.69	229.49±19.21	(Direba 2012)
Jersey	34.51±042	450.09±6.60	---	(Habtamu *et al.* 2010)
HF	40.9±0.33	475±2.84	---	(Berhanu *et al.* 2011)
HF	40.83±0.46	----	----	(Gebeyehu *et al.* 2014)
HF	39.2±7.5	446±91	148±1.72	(Million *et al*. 2010)
HFX Boran	40.32±2.3	461±34	184.72±2.3	(Tadesse, 2014)
HFX Boran	37.42±0.35	476.35±3.91	197.10±3.88	(Kefale *et al*. 2019)
HFX Boran	40.5±0.7	435±11	141±19	(Aynalem *et al.* 2009)
HFX Boran	34.66 ±0.56	----	-------	(Berhanu and Ashim 2014)
HFX Boran	39.49± 0.83	476.36 ±4.73	195.47 ± 4.74	(Wassie *et al*. 2015)
HF X Arsi	42.84± 0.84	475.48±4.08	193.77± 4.06	(Wassie *et al*. 201 5)
HF x Fogera	25.6	1,086	534	Emebet and Zeleke, (2007)

HF= Holstein Friesian, HF x Borana= Holstein Friesian cross with Borana, HF x Arsi= Holstein Friesian cross with Arsi.

Dietary supplementation of heifers during their growth period reported a decrease from birth to age at first service for the interval and age at first calving. Early maturing females are known to have a relatively long and fruitful reproductive life, and thus it determines the rate of genetic progress and population growth rate (Hammoud et al., 2010). The means SD (AFC) (minimum 18 and maximum 36 months), for crossbred cows which have unknown exotic blood level in different parts of Ethiopia, were 26.9±5.4, 36.2, 34.7, 33.2, and 34.8 months, respectively (Mureda and Mekuraiw, 2007; Lemma and Kebede, 2011; Ibrahim et al., 2011; Dinka, 2012; Amin et al., 2013). Usually, local breeded cows do not produce their first calve earlier than 35–53 months of age (Megersa, 2016). The age at first calving for local cows in the Oromia regional state is 52 months, and for crossbreed is 31.06 months (Mureda and Mekuraiw 2007; Ibrahim et al. 2011; Lemma and Kebede 2011; Dinka, 2012).

Table 5. Age at first calving and calving interval

Breed (genotype)	Reproductive trait performance			
	Country	AFC(d) (months	CI(d) (months)	Source
crossbred dairy cattle	Pakistan	1300 (43.33)	543 (18.1)	(Hassan and Khan 2013)
Friesian X zebu cattle	Ethiopia	972 (32.4)	402 (13.4)	(Nibret 2012)
Zebu X H-F	Ethiopia	1115 (37.17)	640 (21.33)	(Belay *et al.* 2012)
Crossbred dairy cows	Ethiopia	1044 (34.8)	372 (12.4)	(Belay *et al.* 2012)
Holstein-Friesian	Pakistan	894 (29.8)	408 (13.6)	(Sandhu *et al.* 2011)
Jersey cows	Ethiopia	1035 34.5)	450 (15)	(Habtamu *et al.* 2010)
Friesian cows	Egypt	921 (30.7)	403 (13.43)	(Hammoud *et al.* 2010)
Jersey cows	Pakistan	1010 (33.67)	487 (16.23)	(Suhail *et al.* 2010)
Holstein–Friesian	Ethiopia	1265 (42.17)	561(18.7)	(Amene *et al.* 2011)
Red Chittagong cattle	Bangladesh	1518 (50.6)	454 (15.13)	(Amin *et al.* 2013)
Friesian X zebu cattle	Ethiopia	1041 (34.7)	419 (13.97)	(Nuraddis *et al.* 2011)
Holstein-Friesiancows	Ethiopia	1272 (42.4)	478 (15.93)	(Besufekad 2008)
Holstein-Friesiancows	Cameron	927 (30.9)	399 (13.3)	(Gwaza *et al.* 2007)
Holstein Friesian	Ethiopia	1176 (39.2)	---	(Million *et al.*,2010)
Holstein Friesian	Ethiopia	1227 (40.9)	----	(Berhanu *et al.*,2011)
1/2 HF x 1/2 Boran	Ethiopia	1146 (38.2)	----	(Destaw. ,2016)
Highland zebu	Ethiopia	1590 (53)	453 (15.1)	(Niraj *et al.* 2014)
Friesian x Boran	Ethiopia	936(31.2)	429.2(14.31)	(Megersa 2016)
Friesian x Boran	Ethiopia	810 (27)	390 (13)	(Dessalegn *et al.* 2016)
Friesian x Boran	Ethiopia	26.5 (795)	463.1(15.44)	(Niraj *et al.* 2017)
Friesian x Boran	Ethiopia	36.6(1098)	640.0 (21.33)	(Belay *et al.* 2012)

d=days, CI=calving interval, AFC=age at first calving

2.2.2. Calving interval dairy cattle (CI)

The calving interval is the period between two consecutive parturitions. The calving interval was subdivided into two major periods. Those were the calving to conception and the gestation periods. The latter is fixed in length, while the former varies depending on the type of breed and nutritional status of the cow. Calving interval varies slightly due to breed, calf sex, calf size, dam age, year and month of calving. In most dairy farms, the calving interval should ideally be 12 to 13 months and should be considered as optimal and achieved when the calving to conception interval was less than 85–105 days (Genzebu et al., 2016).

Calving interval (CI) is one of the major components of reproductive performance that influences systems of the livestock production system. It means SD (minimum 12 months and maximum 21 months). The reasonably short calving intervals of 12–13 months indicate an optimum combination of good management and sound physiological condition of the cow, for CI were 13.0±2.1 and 13.8±1.9 months for cross-breed dairy cattle Cross breeds have slightly shorter calving intervals than indigenous in Tatesa Cattle Breeding Center (622.6 days or 20.753months). A study conducted in the North Showa zone indicated that indigenous breeds have larger calving intervals (748.2 days or 24.94 months) than cross-breeds (660 days or 22 months) (Mulugeta and Belayneh, 2013).

However, in contradiction to expectations, a shorter calving interval at a higher inheritance level, and a calving interval was reported at 75 and 87.5% were cross-breeds respectively. The Calming interval might reveal poor nutritional status, poor breeding management, absence of individual bulls and artificial insemination service, longer days open, diseases and poor administration practices (Belay et al., 2012).

The high grade and Holstein Friesian Cows had significantly longer calved intervals. The mean calving interval for the Barça breed was 401 days, which is lower than the 474 days of calving interval for the Horrow breed in Ethiopia. The research conducted at Abernosa Ranch with Boran x Holstein- Friesian F1 crossbred dairy Cows showed long calving interval (534.3 days), with average breeding efficiency of 44.6% (Mureda and Mekuriaw, 2007). Crossbreeding that involved six genetic groups originated from Barça and Borana and found a mean Calving interval of 400 ± 14 days, 400 ± 14 days, 448 ± 16 days, 436 ± 15 days, 498 ± 30 days and 464 ± 24 days for 1/2Barca X 1/2Friesian, 1/2Borena X 1/2Friesian, 1/4Barca X 3/4Friesian, 1/4Borena X 3/4Friesian, 1/8Barca X 7/8Friesian and 1/8Borena X 7/8Friesian, respectively (Million and Tadelle, 2003a).

The calving interval was shorter in cross-breeds than in indigenous people. Proper management of animals was practiced, as the average calving interval of indigenous cattle breeds and their 50% crosses were 431.5 and 429 days, respectively. It indicated that cross-breeds have slightly shorter calving intervals than indigenous people (622.6 days) as reported and also, another result was reported. In the North Showa zone and Jimma Zone, they indicated that crossbreds of unknown exotic inheritance have calving intervals of 660 and 640.8±3.84 days, respectively (Yifat et al. 2012; Belay et al., 2012; Mulgeta and Belayneh 2013).

On the other hand, the calving interval of crossbreds born from indigenous cows with Holstein Frisian/HF with different exotic blood levels of Arsi X HF of 50%, 75% and 87.5% have calving intervals of 503, 464 and 525 days respectively and crossbred of Zebu X HF of 50%, 75% and 87.5% have Calving interval of 458, 475 and 525 days respectively. Also, crossbreeds of Borana X HF of 50%, 75% and 87.5% exotic blood levels have a calvinging interval of 440, 471 and 493 days respectively and crossbreeds of Barça X HF of 50%, 75% and 87.5% have calving interval of 415, 474 and 512 days respectively (Megersa, 2016).

2.2.3. Number of services per conception (NSC)

The number of services per conception (NSC) is known to be the number of services natural or artificial inseminations needed for a successful conception, the number of inseminations required to produce a live calf is one of the most useful parameters of reproductive efficiency. It is higher under uncontrolled natural breeding than hand mating and artificial insemination. Values of NSC greater than 2 should be regarded as poor. The optimum recommended NSC for profitable dairy cows ranges from 1 to 1.7 (Menale *et al.*, 2011). This depend on the breeding system that is being used and influenced by both non-genetic and genetic factors like season (which is related to availability of feed), semen quality, quantity and parity (Gebrekidan *et al.*, 2012).

The number of services per conception (NSC) depends largely on the breeding system used. It is higher under uncontrolled natural breeding and lower where hand-mating or AI is used. The average number of services per conception of local cows was 1.59. Number of services per conception reported around Mekelle, Bako research center (Tadele and Nibret 2014; Assemu et al., 2016). There are different research findings in Ethiopia on NSC trait, which has been an average value of 1.54 ± 0.1 from HF X Fogera crosses based on station data in north-western Ethiopia. Both 1.69 ± 0.07 and 1.75 ± 0.11, from HF X Horro and Jersey X Horro at Bako research center, 1.67 ± 0.04 and 1.63 ± 0.06, from retrospective data and survey monitor around Adigrate, 1.58 ± 0.07, in eastern Tigray from on farm survey of HF crosses were also reported, from F1 HF X indigenous and Jersey X indigenous, 1.54 from F2 HF X indigenous and Jersey X indigenous and 1.41 from 75% HF X indigenous and Jersey X indigenous crosses. Relatively lower NSC had reported (Wassie et al. 2015) which found

1.32 ± 0.06 and 1.39 ± 0.05 from Friesian X Arsi and Friesian X Borena at Agarfa ATVET College (Haile et al. 2009b). 2.2 ± 0.10, 2.7 ± 0.18, 2.2 ± 0.17 and 1.7 ± 0.11 for 50%, 62.5%, 75%, and 87.5% HF X Borena crosses in Holetta and Debre-Zeite research center, the central highland of Ethiopia (Kefena et al. 2006a; Aregawi 2013; Alemshet 2014; and sisay 2015)

Table. 6.Number of services per conception for different breeds of dairy cows in Ethiopia

Breeds (Genotype)	Reproductive trait performance	Source
	NSPC	
Jersey	1.79±0.06	(Habtamu *et al*. 2010)
Jersey	2.02±0.02	(Direba *et al*. 2015)
HF	1.81	(Million *et al*. 2010)
HF	1.30±0.06	(Mengistu *et al*. 2016)
HF x Borana	1.75 ± 0.03	(Kefale *et al*. 2019)
HF x Borana	2.33±0.1	(Aynalem *et al*.2009)
HF x Borana	1.39±0.05	(Wassie *et al*. 2015)
HF x Arsi	1.32±0.06	(Wassie *et al*. 2015)
Fogera breed	1.54	(Giday, 2001)
Borana	1.61	(Yifat *et al*. 2012)
Barka	1.62	(Gebeyehu *et al*., 2005)
Highland zebu	2.2	(Niraj *et al*., 2014)
HF x Borana	1.8	(Megersa 2016)
HF x Borana	1.8	(Niraj *et al*., 2017)
HF x Borana	1.5	(Belay *et al*.,2012)

HF= Holstein Friesian, HF x Boran= Holstein Friesian cross with Boran, HF x Arsi= Holstein Friesian cross with Arisi, NSPC= number of services per conception.

Number of services per conception (NSC) is the number of services required for a successful conception (Nuraddis et al., 2011). NSC of local cross with Holstein in Gondar is 1.29 (Yifat et al., 2009). In Ziway, for cross-bred cows under small holder condition, they found that the number of services per conception was 1.67-2.0 for cows that are maintained on Asella farm. In Asela, under small holder condition 1.720±0.056 (Negussie et al., 1998; Gebayehu et al., 2005; Meseret et al., 2014).

The mean value for the number of services preconceptions of the Boran breed and Arsi zebu breed was 2.17 and 1.18, respectively (Yifat et al., 2009). It revealed that the parity number and season of previous calving significantly affected NSC ($P < 0.001$). They found that lower values of NSC (1.45) were found in cattle with 3 or more calving. Similarly, a significant effect of parity on NSCP ($P<0.05$), it was reported that the overall mean for NSC of cross-bred cows in the eastern lowland of Ethiopia across all systems was 2.16 (Gebayehu et al., 2005; Mureda and Mekuriaw 2007).

2.2.4. Days open (DO)

Days open denotes the interval from calving to the day of conception and includes the postpartum anoestrous interval and service period (i.e., the number of days between parturition and the insemination that resulted in a pregnancy. Days open (DO) is the most variable but the determining component of the calving interval. It is mostly influenced by the length of time for the uterus to completely involute, resumption of normal ovarian cyclicity, occurrence of silent ovulations, accuracy of heat detection, management decisions on how soon to rebreed following parturition, fertility of a bull (semen) and efficiency and skill of inseminator.

Days open affect lifetime production and generation interval (Niraj, et al., 2014).185.8± 51.2 (Mekelle) and 88.13 ±2.03 (Horro) days for dairy cows, respectively, Year of calving has a significant effect on DO but season of calving did not affect DO (Niraj, et al., 2014). However, there is a significant effect of parity numbers, summer season and season of calving has significant effect on DO, this affect the lifetime productivity and calve crop of cow and this parameter is affected by management of cow and proper heat detection (Chenyambuga and Mseleko 2009).

Borana and their crosses with Holstein Friesian of five genetic groups in the central highland of Ethiopia, days open values were 141 ± 7 days, 127 ± 7 days, 135 ± 8 days, 142 ± 8 days and 134 ± 14 days for pure Borena, 50%, 62.5%, 75% and 87.5%, at Bako research center, 91.46 ± 1.29 and 79.18 ± 2.00 for HF X Horro and Jersey X Horro crosses, these indicated that Jersey X Horro was lower DO than HF X Horro crosses. These results indicated the presence of genetic differences of both HF and Jersey in the performance of DO and CI (Sisay 2015). Days open trait can be influenced or not influenced by non-genetic factors like season of calving, year of calving and parity. However, there is non-significant influence of the open season on open days (Haile et al., 2009b; Deriba, 2012; Mengistu et al., 2016). Unlike these results, the significant effect of season on DO trait (Wassie et al. 2015).

Table. 7. Days open and number of services per conception.

Breed (Genotype)	Reproductive trait performance,			Source
	Country	DO (d)	NSC	
Holstein–Friesian	Ethiopia	174	2.01	(Yosef 2006)
Holstein–Friesian	Ethiopia	177	1.72	(Gebeyehu *et al*. 2007)
Holstein–Friesian	Ethiopia	206	2.1	(Besufekad 2008)
Friesian cows	Egypt	130	2.1	(Hammoud *et al*.2010)
Holstein–Friesian	Ethiopia	285	1.69	(Gizaw *et al*. 2011)
Friesian X zebu cattle	Ethiopia	171	1.29	(Nuraddis *et al*. 2011)
Horro x Friesian	Ethiopia	123	1.97	(Gizaw *et al*. 2011)
Horro x Jersey	Ethiopia	109	1.92	(Gizaw *et al*. 2011)
Tunisian Holstein cows	Tunisia	150	2.55	(M'Hamdi *et al*. 2011)
Cross-bred dairy cows	Ethiopia	85	1.52	(Hunduma 2012)
Zebu X Holstein Friesian	Ethiopia	155	1.56	(Belay *et al*. 2012)
Friesian X zebu cattle	Ethiopia	87	1.3	(Nibret 2012)
Iranian dairy cattle	Iran	111	2.1	(Motlagh *et al*. 2013)
Crossbred	Ethiopia	218.5	2.2	(Emebet and Zeleke, 2007)
HF x Borena	Ethiopia	134.84±3.51	1.36±0.03	(Mengistu *et al*. 2016)
75% Friesian	Ethiopia	169.17±3	1.59±5	(Kefena *et al*. 2006a)

d=Days, DO=Day open, NSC=Numbers of service per conception.

In Tanzania for Ayrshire and Boran cross, the overall mean length of the days open period was 100.7 ± 3.6 days, 200.13 ± 25.55 days for cross breeds in highland of Ethiopia. Comparable DO of 5.7 months (171 days) of cross breeds cattle were in Gondar, Ethiopia (Kefena *et al.*, 2006; Nuraddis *et al.*, 2011). Similarly, the lowest DO of 121 days for Friesian Zebu crossbred cows at Assela livestock farm. Furthermore, 85.6±5.6 days, DO for cross breed cow at small holder level, the range of DO was from 129.63 to 281.33 (Sattar *et al.*, 2005; Suhail *et al.*, 2010; Dinka 2012).

2.3. Estimation of Genetic Parameter

The majority of tropical (indigenous) cattle breeds are low producers of milk with high individual variability, which is attributed to natural selection for the tropical environment and management. To improve their performance, the introduction of high-producing exotic breeds (Holstein-Friesian, Jersey, and Simmental), has been playing an important role. The performance of these breeds is often affected due to genotype and environmental interaction. One of the best methods for solving this problem could be crossbreeding as a mating system to optimizes the additive genetic and non-additive (heterotic) breed effects of Bos taurus and Bos indicus cattle in sustainable breeding systems and increasing genetic increased them (Gebregziabher et al., 2014).

Genetic parameters are desirable for genetic development programs to forecast the breeding values of candidates for genetic selection, to select between breeding plans and to forecast selection response (Montaldo et al., 2010). The genetic composition of a population can be studied by considering the comparative importance of heredity and environmental factors affecting the performance of individuals in that population (Gebeyehu 2014). Awareness of genetic parameters, viz, the heritability and genetic associations among traits helps in determining the suitable selection method and breeding system. The most frequently used parameters for estimating genetic parameters are repeatability, heritability and genetic correlation, relevant to the actual use. Genetic variability is knowledge of the genetic and environmental relationships between the characters which includes heritability and repeatability of the characters and the genetic phenotypic and environmental correlations among them (Yibrah, 2008).

Accurate and correct information about genetic parameters is of paramount importance for developing suitable selection and breeding plans for genetic development programs. The potential for genetic development of a trait mainly depends upon genetic differences present in a population of interest. The variability for a specific trait in a herd or population is measured by heritability estimate of a trait under assumed environmental conditions. The genetic parameters have been reviewed in terms of heritability, repeatability and association estimates of replacement rate and selective value and lactation traits (Gebeyehu 2014).

Variance mechanisms and genetic parameters are required for genetic development programs to forecast the breeding values of candidates for genetic selection, to choose among breeding plans and to predict selection reply. The plan now employed in Ethiopia to raise milk yield is by crossbreeding locally adapted indigenous breeds capable of withstanding heat stress, diseases, low feed source and low management level with exotic dairy breeds of high genetic ability for milk yield. This breeding system has resulted in a variety of cross-bred groups with diverse levels of additive and non-additive genetic capacities (Gebregziabher et al., 2013).

2.3.1. Variance Component of Productive and Reproductive Traits

Phenotypic variation was due to genetic and environmental factors which are association or interaction of both. The relative magnitude of the component determines the genetic properties of the population, in particular the degree of similarity between relatives. Addictive genetic variance (σ 2 a), which is the variance of breeding value, was the main cause of similarity between relatives, therefore the major determinant of the observable genetic properties of the population and the response of the population to selection. Variance components and genetic parameters were needed for genetic improvement programs to predict the breeding values of candidates for genetic selection, to select between mating plans and to forecast selection response (Montaldo et al., 2010).

Information about the type and quantity of genetic difference and supply of animals for traits considered for selection in the population can help to design optimum breeding programs. Addictive genetic differences have been instrumental in populations the genetic development of traits of economic importance in dairy cattle populations, and estimation of genetic parameters in Ethiopian cattle has been scanty. This might be attributed to lack of well-structured pedigree data and lack of farm records. However, some estimates of genetic parameters (variance component, heritability and repeatability) of productive and reproductive traits (Haile et al., 2009a; Kefena et al., 2011; Gebregziabher et al., 2013).

2.3.2. Heritability

Heritability is important among several factors which determine how much genetic improvement can be made in any trait. Heritability is critically important for selection of polygenic traits. Heritability estimates show a high level of variability that is a result of the variances in the population structure of the herds that provided the data, model fitted for analysis, estimation procedures, breed and environment where data was obtained, size of the data set and nature of data cleaning, the low heritability is caused not only by a low genetic variance but also by a higher phenotypic variance due to small size of the herd and by random or unidentified environmental factors, heritability values for production and reproduction traits like milk yield and AFC tend to vary more in the tropics than in the temperate region, which indicates the difference in the additive, environmental and random error variance components between the two ecological regions (Aynalem, and Wasike, 2006).

Heritability value of 0.29 ± 0.04 and 0.30 ± 0.04 for lactation yield and daily milk yield traits, respectively in multi-bred dairy cattle population in Ethiopia, genotype environment interaction of lactation pattern and reported the value of 0.29 ± 0.12 and 0.34 ± 0.13 for LMY and DMY at Bako and 0.26 ± 0.08 and 0.26 ± 0.08 for LMY and DMY at Holetta research center, heritability value of 0.24 ± 0.03, 0.19 ± 0.03, 0.13 ± 0.03 for LMY, DMY and LL of Borana and its crosses with Friesian and Jersey in Ethiopian highland, a value of 0.10 ± 0.002, 0.45 ± 1.05 and 0.63 ± 0.02 for LMY, DMY and LL traits, respectively, heritability estimates of crossbred dairy cows were 0.14, 0.44 and 0.38 for lactation length, lactation milk yield and 305-day milk yield, respectively. This implies that heritability estimation was specific for breed, management and geographical location from which data were obtained, (Demeke et al. 2004a; Haile et al. 2009a; Kefena et al. 2011, and Gebregziabher et al. 2013).

Most reproductive traits are extremely influenced by differences in herd management practices and other environmental factors rather than genetic factors. However, sire selection can cause obvious differences in the reproductive performance of herds in the long term (Yosef, 2006). Estimation of heritability value of reproductive traits of crossbred dairy cattle are 0.44 ± 0.05, 0.08 ± 0.03, 0.04 ± 0.03 and 0.07 ± 0.02 for AFC, CI, DO and NSC, respectively (Haile et al. 2009b). On the other hand, a heritability value of 0.1 ± 0.046, 0.1 ± 0.047 and 0.1 ± 0.071, for CI, DO and NSC with higher heritability values of AFC (0.7 ± 0.159 (Kefena et al. 2011). Friesian and Jersey crossed with Borana for different traits and found that heritability estimates of age at the first calving and calving interval were 0.40, 0.38 and 0.17, respectively. At Metekel ranch, a heritability estimate of 0.26119, 0.149, 0.049 and 0.010 for AFS, AFC, CI and DO traits for HF X Fogera crosses from bi-variate analysis, respectively (Belay 2014).

2.3.3. Repeatability

In dairy cattle, the repeatability estimates refer to the strength of the relationship or correlation between repeated records of a trait in a population and this may be utilized to assess the real producing ability of individual dairy cattle in the population (Olawumi and Salako, 2010). The repeatability value is greater than the heritability value since repeatability estimates include the permanent environmental variance in addition to the additive genetic variance component. When repeatability is high, we can assume that a single record of performance in an animal is, on average, a good indicator of that animal's producing ability.

When repeatability is low, a single phenotypic value tells us very little about producing ability. Cows should not be culled based on single (or only a few) initially available records. Lower repeatability estimates for traits could also be due to higher influence of specific environmental effects on a given record that may expand within animal records variability (Haile et al., 2009). Some repeatability values for milk production traits of crossbred dairy cattle in Ethiopia were 0.39 ± 0.02, 0.30 ± 0.02 and 0.19 ± 0.02 for LMY, DMY and LL, respectively (Demeke et al. 2004a). On the other hand, the overall repeatability value of 0.53 ± 0.01, 0.51 ± 0.02 and 0.21 ± 0.02 for LMY, DMY and LL traits, respectively, at three on station (Bako, Debre Zeit, and Holetta) research data, which have genetically linked crossbred population with sires supplied from NAIC (Gebregziabher et al. 2013). Repeatability of reproductive trait of crossbred dairy in the tropical high land of Ethiopia, 0.14 ± 0.02, 0.14 ± 0.02 and 0.08 ± 0.01 for CI, DO and NSC, respectively, an approximate average repeatability value of 0.10 and 0.11 for two economic traits (CI and DO) for Borana and Friesian crosses with different genetic group in central Ethiopia (Haile et al. 2009b; Gebregziabher et al. 2013).

2.3.4. Breeding Value

Estimation of breeding value needs to be based on trait measurements, either on the animal or on the animal genetically related to the individual. Estimation of breeding value based on phenotypes can be an accurate assessment of breeding value based on the performance of the offspring of the animal, and it requires a sufficient number of progenies to be tested. Selection of bulls based on pedigree information can support the fastest genetic improvement. Breeding value estimation in Ethiopia was scanty, while some studies have shown that variations were observed among sires in their breeding values based on breed of sire, number of progenies studied and geographical location (Gebregziabher et al., 2013).

Estimated five sires (Friesian, Jersey, Simmental, Horro and Borena). Also, their estimated breeding values (EBV) were ranged from -392.5 to 1,962 kg for LMY, -1.8 to 7.4 kg for DMY and -26.3 to 139.4 days for LL, which is computed by using Best Linear Unbiased Prediction (BLUP) solution, was evaluated the performance of Friesian and Jersey sires for different traits in central Ethiopia, the estimated breeding values of Jersey sire was ranged from -30 to 24 kg for 305 days milk yield, - 228 to 57 day for AFC, -3 to 13 days for CI and -29 to 54 days for DO traits while the estimated sire breeding values of Friesian was –456 to 1232 kg for 305-days milk yield, –5 to 3 months for AFC, -55 to 10 days for CI and -57 to 24 days for DO traits (Yosef, 2006).

2.4. Non-genetic factors affecting production and reproduction Performances of Cross breed dairy cattle

2.4.1. Non-genetic Effects on Milk production traits

Parity non-genetic effects on milk production traits have been explained by different researchers. The effect of lactation days on cumulative milk yield of Holstein Friesian cows at 305 days (Ahmed et al., 2007; Guler et al., 2009). Parity has a significant effect on the LMY of Friesian cows in tropical management. Furthermore, crossbred cows of different Holstein Friesian inheritance (50, 75, 87.5 and 100%), revealed that first-second and third-parity dams yielded more milk than fourth-parity dams (Ngodigha; Etokeren, 2009). On other hand it indicated that first parity (4554±469kg), second parity (5427±455 kg) and third parity dams (5139±441 kg) yielded more milk than fourth parity dams (2896±430 kg) (Addisu et al., 2010). This shows that parity of cows significantly affected daily milk yield (P< 0.0 I), and had significant effects on lactation milk yield of Holsteian Friesian cows, (Million et al. 2010).

Season; - season of calving (P<0.03) has significant effects (fisseha 2007). Whereas season of birth has no significant effects on lactation milk yields of Holstein Friesian heifers. Contrast (million et al., 2010). Mentioned that calving season has a significant effect on lactation milk yields. However, non-significant effects of calving season on LL in Ethiopia and Uganda (Mulindwa et al. 2006). Whereas environmental deviations (heat stress in summer especially) coupled with fodder scarcity were the main reasons for low milk production (Javed et al., 2004).

Year - Year of calving had a highly significant effect on the first LMY, but had no significant effect on the LP of Friesian cows in Egypt (Addisu et al., 2010). For Fogera, the breed indicated that parity of cow and year of calving significantly affected daily milk yield, while the season of calving had no significant effect on DMY (Amasaib et al., 2008). For Friesian crossbred in India. Mean lactation milk yield increased with the increase in parity, to attain a peak value at third lactation showed that year of birth, year of calving, season of calving, and parity had significant effects, whereas season of birth had no significant effect on LMY, in contrary to these Calving season and parity has significant effect on LMY, (Javed et al., 2004; Fisseha 2007; million et al., 2010). Whereas, environmental deviations (heat stress in summer especially) coupled with fodder scarcity were the main reasons for low milk production, the differences between parity three to six were not significant. However, after parity, six declining trends were observed. Improving environmental conditions and management practices, coupled with improved genetic potential of dairy animals would be the more effective approach to high milk production (Million et al., 2010).

2.4.2. Non-genetic Effects on reproduction traits

Year, deterioration of fertility traits seems to be caused by a combination of various environmental and management factors, which start at calving, and all have an additive effect on reproductive efficiency. Fertility traits have a high environmental component, which implies that genetic improvement through selection is likely to be a slow process (Craig et al., 2018). The year of calving has a significant influence on the AFC, CI and NSC of Holstein Friesian cattle in Malawi (Bruns et al., 2004).

Parity, on the other hand, number of services per conception (NSC) was significantly influenced by parity and the herd of herds, while the period and season of calving had no significant effect on the Holstein Friesian cattle in Ethiopia. (Million et al., 2010). Successful service or insemination depends on many factors such as quality of semen, skill of the inseminator, proper time of insemination and cows' condition related factors. Management, nutrition and climate conditions may also affect the success of insemination. The effect of herds of cows was significant on service per conception (SPC, DO and CI), of Holstein Friesian dairy cattle in Ethiopia (Yifat et al., 2009; million et al., 2010).

The number and season of previous calving significantly affected the (NSC) of cross-bred cows in the on ziway. The lower values of NSC were found in cattle with three or more calving. Similarly, a significant effect of parity on NSC was reported by (Gebayehu, et al., 2007). Effects between season of birth and year of birth show significant effects on age at first calving of Egyptian Holstein Friesian cattle (Almasri et al., 2020). Calves born in the dry season tend to be younger at first service and calving than those born in the short and long rainy season of Holstein Friesian at Alage dairy farm (Fekadu et al., 2010). In Tanzania, it showed that the year of calving, the season of calving and parity significantly affected the length of the days-open period (Chenyambugaand, Mseleko 2009).

Season; - service per conception was significantly ($p<0.001$) influenced by parity and herds of animals (Million, et al .2010). While the period and seasons of calving have no significant effects on the Holstein Friesian cattle in Ethiopia (Yifat, et al.2009). It is revealed that the season preceding calving significantly affected service per conception (NSPC), ($P<0.001$) of crossbred cows in Ziway (Emebet and Zeleke, 2007). Calves born in the dry season tended to be younger at first service and, calving than those were born in short and long rainy season of Holstein Friesian at Alage dairy farm, (Amene et al.,2010; Chenyambuga and Mse1eko 2009). In Tanzania, it showed that the season of calving significantly ($p<0.05$), affected the length of the days open (Getinet, et al. 2009). Observed that season has a significant effect on birth weight (BW). Season of birth ($p<0.05$) has significant effects on birth weight of calves (Habtamu et al. 2010).

Other factors: The fixed effects of herds of cows were significant ($p< 0.001$) on service preconception (NSC), days open (DO) &calving interval (CI) of HF dairy cattle in Ethiopia (Million et al., 2010; Nibret, 2012; Tadele and Nibret, 2014). Feed scarcity, absence of access to land, disease occurrence, low level of management, poor breeding organisation, for example, absence of exact heat detection & appropriate insemination might have contributed to poor reproductive performance of local & their cross-breed dairy conditions in urban and peri -urban areas of Gondar, agro-ecology was important cause of difference for age at first service periods of crossbred of heifers, but non-significant effect of agro-ecology on CI rate in high producing lactating Cows (Tsegaye, et al., .2015).

3. MATERIALS AND METHODS

3.1. Description of the Study

The study was conducted at Holeta and Debre-Zeit agricultural research centers, which are administered under the Ethiopian Institute of Agricultural Research (EIAR).

3.1.1. Description of Holeta Agriculture research center area

Holeta Agriculture Research Centre (HARC) is situated approximately 29 km west of Addis Ababa. Geographically, it is located between (38.5°E longitude and 9.8°N latitude), in the central high lands of Ethiopia with an altitude of 2400 meters above sea level (m.a.s.l.). The periods of substantial rainfall may occur during the rainy season and the area obtains an average rainfall of 1144 mm.

Based on rainfall distribution, the area is differentiated into three main rainy seasons in the year. This is a long rainy season extending from June to September. The dry season continues from October to February, followed by a short rainy season having light rain which extends from March to May. The average minimum and maximum every-day temperature of the area was reached from 6 to 15°C and 18.7 to 24.0°C, respectively. The average monthly relative humidity is 60%. (HARC, 2008; Tadesse et al., 2015; Getahun et al., 2019; Fikadu, 2021).

3.1.2. Description of Debre- Zeit, Agriculture Research

Debre-Zeit Agriculture Research center is located approximately 50 km south-east of Addis Ababa, in the Ethiopian highlands. Geographically, it is located between (9N latitude and 39E altitude) in the high lands of Ethiopia with an altitude of approximately 1850 metres above sea level (M.a.s.l).

The periods of substantial rainfall may occur during the rainy season and the area has an average rainfall of approximately 866 mm. Based on rainfall distribution, the area is differentiated into three main seasons in the year. There is a long rainy season extending from June to September; the dry season continues from October to February, followed by a short rainy season having light rain which extends from March to May. The mean annual minimum and maximum temperatures are, 8.9°C and 28.3°C, respectively, with an average of 19°C. The mean relative humidity is 61.4% (DZARC, 2008; Haile et al., 2011; Tena, 2014).

3.1.3. Herd Management at Debre Zeit agriculture Research Center

The cattle herding at the research center is managed based on gravidity, lactation stage (physiological status), breed, sex and age. Uniform circumstances of nourishing and management practices are for all animals. All animals have been recognized using plastic ear tags within 24 hrs after birth. The animals were left to graze on a natural meadow from early morning, 8:00 AM to 4:00 PM, in the afternoon, allowed to graze around 8:00, hours during daytime, and at night all animals kept in their shed and provided by natural pasture hay, which was harvested from on station grazing field, which used as a basal diet, and distillate supplements constitute is the main feed supply,

Cows, heifers and calves were supplemented with a concentrated mixture of feed, based on the animals' body weight, productivity and physiological categories. A distinct pen is expected for each animal, and as required, they have access to clean tap water. In the research center, calves are permitted to suckle their dam immediately after natal for about four days to benefit from colostrum. After four days, calves were taken in to the calf's rearing pen and continued to feed a fixed amount of 2-2.89 lit/d (260 liters of whole milk) for about 3 months through an artificial feeding scheme (bucket feeding). Weaned calves were transferred to another pen and kept on the door until six-months of age. The shed was cleaned every day, together with technical hand milking and machine milking, accustomed to milking the dairy cows. All undesirable masculine calves and fruitless animals were culled from the research 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 were taken according to the disease control calendar set by the animal health research division of the Debre-Zeit research center, in addition, vaccination against Rinder pest, Foot and Mouth disease, (FMD). Anthrax, Pasteurolsis, Blackleg and Contagious Bovine Pleuropneumonia (CBPP) are given to the farm animals. They are also drenched and sprayed for internal and external parasites at regular intervals. Artificial insemination, (AI) by semen introduced to semen, from Livestock development institute (L.D.I.) or purchased from world-wide, has been used for breeding purposes.

3.1.4. Breeding program of DZARC

The breeding system of HF x local breeds produced diverse genetic groups of heritances like (50%, 62.5%, 75%, and most efforts were on high-grade blood levels of 87.5%, up to 99.22% and 99.60%). Borana breeds (Indigenous cattle breeds) used as a basis stock for cross-breeding were brought by Borana pastoralists in the southern parts of Ethiopia and reared on-station, then bred randomly with HF sire semen, which is processed in the LDI and Worldwide semen (WWS) to get the important generations.

The breeding work at the research farm was practiced throughout the year by means of artificial insemination (AI), which transported semen from locally recruited crossbred bulls or pure Friesian from LDI. Worldwide sires (WWS) Bulls born at the farm were selected for breeding purposes based on dam milk performance and physical conformation for semen collection in LDI and used for on-station breeding activities and care was taken throughout bull selection for LDI to avoid genetic association.

3.1.5. Herd Management at Holeta agriculture Research Centre

The cattle herding at the research center is managed based on gravidity, lactation stage (physiological status), breed, sex and age. Uniform circumstances of nourishing and management practices are for all animals. All animals have been recognized using plastic ear tags within 24 hrs after birth. The animals were left to graze on a natural meadow from early morning, 8:00 AM to 4:00 PM, in the afternoon, and allowed to graze around 8:00, hours during daytime, and at night all animals kept in their shed and provided by natural pasture hay, which was harvested from on station grazing field, which used as a basal diet, and distillate supplements constitute is the main feed supply.

Supplemented feed is provided based on their body weight, productivity and physiological categories. Milking cows, heifers and calves were supplemented with concentrate mixture at a rate of 4 kg, 1-1.5 and 0.25-1 kg per day, respectively. A concentrated pen is predictable for each animal, and as required, they have access to clean tap water. In the research center, calves are permitted to suckle their dam immediately after natal for about four days to accept colostrum. After four days, calves were taken into the calf's rearing pen and continued to feed a fixed amount of 2-2.89 lit/d (260 liters of whole milk) for about 3 months through an artificial feeding scheme (bucket feeding).

Weaned calves were transferred to another pen and kept on the door until six-months of age. The shed was cleaned every day, together with technical hand milking and machine milking accustomed to milking the dairy cows, all undesirable masculine calves and fruitless animals were culled from the research 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 were taken according to the disease control calendar set by the animal health research division of the Holeta research center, in addition, vaccination against Render pest, Foot and Mouth disease, (FMD). Anthrax, Pasteurolsis, Blackleg and Contagious Bovine Pleuropneumonia (CBPP) are given to the farm animals. They are also drenched and sprayed for internal and external parasites at regular intervals. Artificial insemination, (AI) by semen is introduced by the Livestock development institute (L.D.I.) or purchased from worldwide. Purposes have been used for breeding purposes.

3.1.6. Breeding program of HARC

The breeding system of HF x Boren produced diverse genetic groups (50% F1, F2, F3 and a few efforts were at high grades of 62.5%, 75% and 87.5%). However, the 62.5% and 87.5% high-grade progress were terminated, and further attention is nowadays being made at HARC for the development of 50% F1, F2, F3, 75% F1 and F2 crossbred dairy. Pure Boren dams have bred with pure Friesian semen to produce the 50% F1 crosses while the 50% F1 is crossed back with pure Friesian semen to produce the 75% first generation.

The later generations (F2 and F3) were produced by inter se cross, 50% male with 50% female and 75% male with 75% female, to produce a synthetic breed at 50% HF and 50% Boren and 75% HF and 25% Boren blood level, respectively. The Boren cattle used as a basis stock for hybridisation were brought by Boren pastoralists in southern Ethiopia and reared on-station, then bred randomly with LDI and Worldwide semen (WWS) to get the important generations.

The breeding work at the research farm was practiced throughout the year by means of artificial insemination (AI), which transported semen from locally recruited crossbred bulls or pure Friesian from LDI. World sires and occasionally natural service was used when animals became repeat breeders with AI. Bulls born in the farm were selected for breeding based on dam milk performance and physical conformation for semen collection in LDI and used for on-station breeding activities and care was taken throughout bull selection for LDI to avoid genetic association. Since 2010, crossbreeding of Boren cows by exotic Friesian bulls using worldwide sire (WWS) imported semen by ALPPIS/Addis livestock production and productivity improvement service was initiated to further improvement, selection and milk production as a new activity at HARC.

3.2. Data Source and Data Collection

The data for this study was obtained from long-term records of local and cross-bred dairy cattle that have been managed for crossbred research of dairy cattle herds of the Ethiopian Boren breed, and Ethiopian Borana x Holstein Friesian (HF) crossbred dairy cattle maintained at Holeta and Debre-Zeit agriculture research center dairy farms. The study was carried out to estimate genetic parameters of productive & reproductive performance traits of crossbred dairy cattle based on the data source of, age at first calving (AFC), days open (DO), number of services per conception (NSC), calving interval (CI), lactation milk yield (LMY) and lactation length (LL) using data recorded for long periods of time on the two different research stations was extracted for the study.

The performance recorded data on milk production and reproduction traits of local and cross breed cows obtained from long-term periods that were calved between the years, of 1988 to 2021 G.C. for DZARC, and 1974 to 2020 G.C. for HARC. cross bred research on dairy herds of Ethiopian local bred X Holstein Friesian (HF) crossbred dairy cattle maintained under the research stations and hence Borana and different crossbred ranging from 50% to 75% of HF blood levels for HARC, and from synthetic blood level up to high grade blood level breeds (50% to 99.60%.) of HF blood levels for DZARC, were used in this study.

Record books from both Agriculture Research centers contained breeding activities, dam and sire ID, cow ID, dates of birth, calf ID, service date and calving dates, lactation milk yield, (LMY) daily milk yield (DMY) health record, individual card records in which individuals' complete data was prepared, that transferred from herd book, which was contained, disposal date, cause of disposal and other production and reproduction data.

From the collected information, the following production and reproductive traits were derived; age at first calving (AFC), calving interval (CI), number of services per conception (NSC), days open (DO), lactation milk yield (LMY) (litre) and lactation length (LL) (day), was collected, from the Centres, Identification number of each cow, parity, breed group, sire of cow, dam of cow and disposal date to be considered and analysed. All data has been coded and recorded using Excel sheet 2010 windows for both productive and reproductive traits.

3.2.1. Data management

The production and reproductive performance data were collected from 1974 --2020 at Holeta dairy research center, and 1988 -- 2021 at Debre Zeit dairy research center, that have been recorded for the last 46 and 33 consecutive years, were used for this study. Microsoft Excel 2010 was used to arrange and filter milk production data.

Data screening was made to avoid management errors during data entry and editing. Cows that have abnormal calving (i.e., abortion and stillbirths) were not included in the analysis. During data editing, lactation records having less than 110 days were removed from the data set for analysis of lactation milk yield and lactation length. Lactation records of sixth and above parities were pooled together in to sixth due to a few numbers of observations. The major genetic and non-genetic effects were classified into different sub-classes in order to quantify their effect on milk performance traits. The fixed effects in the model were, animal group (breed), year, season and parity are considered for analysis.

The animal group (breed), includes indigenous breeds and cross-bred dairy cattle maintained on the farm (bred animals had different blood levels which had been crossed and raised on the farm). Calving years: Years which were used for this study were spread over the span of 46 years, for Holeta and 33 years for Debre Zeit research center. Thus, there could be variation in the expression of different economic traits over the years due to the effect of changing climatic, feeding and management factors in the herd.

However, this effect might be insignificant to quantify for each year separately. This was initially done, and it was learned that the economic traits didn’t vary over the years in a consistent and meaningful manner, as well as variation of number of observations. Consequently, it was decided to use a period (year group) to account for its effect.

3.2.2. Debre-Zeit research, Delivery period

Thus, the entire duration for cross-breeds is classified into 10. Periods are based on calving years; each year of the period is as follows: P1. 1992 --- 1994, p2. 1995 ----1997, p3. 1998 --- 2000, p4. 2001--- 2003, p5. 2004—2006, p6. 2007 – 2009. P7.2010 – 2012. P8.2013 – 2015, p9.2016 – 2018. P10. 2019- 2021.

Birth period for the crosse breed, each birth period is classified into 10 periods based on birth years; each birth period is as follows: P1. 1988 --- 1990, P2. 1991 -- 1993, p3.1994 --- 1996, p4. 1997--- 1999, p5. 2000—2002, p6. 2003 – 2005. P7. 2006 – 2008. P8.2009 – 2011, p9.2012 – 2014, p10.2015 – 2017 for Debre -Zeit research center.

The entire duration for local breeds is classified into 10 periods based on calving years; each year of the period is as follows: P1. 1991 --- 1993, p2. 1994 ----1996, p3. 1997 --- 1999. P4, 2000--- 2002, p5. 2003 --- 2005, p6. 2006—2008, p7. 2009 – 20011. P8.2012 – 2014. P9.2015 – 2017, p10.2018 – 2020.

Birth period for local breed, each birth period classified in to 10, period based on birth years; each birth periods as follows: P1. 1988 --- 1990, P2. 1991 -- 1993, p3.1994 --- 1996, p4. 1997--- 1999, p5. 2000—2002, p6. 2003 – 2005. P7. 2006 – 2008. P8.2009 – 2011, p9.2012 – 2014, p10.2015 – 2017. P11, 2018 –2021 for Debre -Zeit research center.

3.2.3. Holeta research, Birth period

Thus, the entire duration for cross breeds birth were classified in to 11. periods based on birth years; each birth periods as follows. P1.1974 --- 1977, P2. 1978 ---- 19,81 p3.1982 --- 1985, p4. 1986 --- 1989, p5. 1990-- 1993, p6. 1994 -- 1997, p7. 1998 --- 2001, p8. 2002 -- 2005, p9. 2006 -- 2009, p10. 2010--2013, p11.2014 – 2017.

Delivery period, for crossbreeds, each calving period was classified in to 10, period based on calving years; - each calving periods as follows,

P1.1982 -- 1984, p2.1985 -- 1988, p3.1989 -- 1992, p4.1993 -- 1996, p5.1997 -- 2000, p6.2001 -- 2004, P7.2005 -- 2008, p8.2009 -- 2012, p9, 2013-- 2016, p10,2017 -- 2020, for Holeta research center.

Thus, the entire local breed is classified into 11 periods based on birth years; each birth period is as follows. P1.1974 --- 1979, P2. 1980 ---- 1982, p3.1983 --- 1985, p4. 1986 --- 1989, p5. 1990-- 1993, p6. 1994 -- 1997, p7. 1998 --- 2001, p8. 2002 -- 2005, p9. 2006 -- 2009, p10. 2010--2013, p11.2014 -- 2017,

Delivery period, for local breeds, each calving period was classified into 13 periods based on calving years; - each calving period is as follows:

P1.1982 -- 1984, p2.1985 -- 1987, p3.1988 -- 1990, p4.1991 -- 1993, p5.1994 -- 1996, p6.1997 -- 1999, P7.2000 -- 2002, p8.2003 -- 2005, p9,2006-- 2008, p10,2009 -- 2011, P11.2012---2014. P12.2015---2017, P13.2018 ---2020 for Holeta research center.

3.3. Method of data analysis

Before starting data analysis, the data were screenings to avoid man-made errors during data entrance of an individual animal card or in computer writing. The lactation milk yields were those with incomplete data, or because of too short or too lengthy point of more than or less than,110 days, for LL, which was observed as incomplete lactation for analysis of productive traits including, lactation milk yield, daily milk yields, and lactation length, (LMY, DMY and LL)and Multivariate analysis for five reproductive traits, age at first calving, calving interval, days open and number of service per conception(AFC, DO, CI .and NSC) were undertaken for estimation, using WOMBAT genetic analysis software package version of 23- 07- 2019, which is developed by Karin Meyer was used to determine variance components and genetic parameters (heritability, repeatability and genetic and phenotypic correlations).

Year, season, parity and breed (genetic group) were fitted as affixed effects in the model. Lactation records of the above 6th parities were pooled together in parity 6th because of insufficient data records. The animals that have abnormal calving, i.e., abortions and stillbirths were not encompassed in the analysis of breeding data. Records of animals without pedigree information and dates of birth and calving were omitted. The animal ID (name) which appeared before their parents was edited and recorded for pedigree analysis.

Table 8. Number of records used in each locations

Traits	Holeta research centre			Debre Zeit research centre			Total
	crosse	Local	Sub total	crosse	Local	Sub total	
Cows	7282	1209	8491	911	215	1126	9617
Dam	6052	296	6348	911	215	1126	7474
Sires	6031	296	6327	911	215	1126	7453
Sub total	19365	1801	21166	2733	645	3378	24544
LMY and LL	7282	1505	8787	1126	888	2014	10801
AFC and CI	4020	1259	5279	341	260	601	5880
NSC, DO	7282	1505	8787	1125	693	1818	10605
Total	18584	4269	22853	2593	1841	4434	27286

3.3.1. Statistical analysis

All collected data were entered into Microsoft Excel 2010 and descriptive statistics such as mean, frequency and percentage were used to analyze the data using SPSS software for statistical analysis (version 20.0 Armonk, NY. IBM corp.).

3.3.2. Fixed effect analysis

To identify the effects of genetic and non-genetic factors (level of exotic gene inheritance, parity, year of birth/calving, season of birth/calving), a preliminary analysis was performed using lm package of R version 4.1.2 (Core Team, 2020). Besides estimating the magnitude of fixed effects, this analysis provided basic information about the significant fixed effects included in the subsequent genetic analysis. The statistical significance of fixed effects was tested by Tukey Kramer multiple Comparison tests at $\alpha < 0.05$.

The following statistical models were used for analysed milk production and reproductive traits in both agricultural research centers.

Model.1. For Reproductive traits AFC, At Holeta and Debre Zeit cross breed

Yijkl = μ + Si + Yrj + Bk + eijkl …………………………………… 1

Where: -

Yijkl= AFC of l^{th} record AFC, of K^{th} blood level, (50 – 75% and 75%),

i^{th} season of birth, (i = Long rainy, Short rainy and Dry seasons)

μ = overall mean

Si = the fixed effect of i^{th} season of birth,

Bk=the effect of k^{th} breed group (k=Borana breed, and Holstein-Friesian-cross with, Borana)

eijkl = random residual error term breed for both centers,

Model.2. For Reproductive traits AFC, At Holeta and Debre Zeit Local Borana breed

Yijkl = μ + Si + Yrj + Bk + eijkl …………………………………… 2

Where: -

i^{th} season of birth, (Yijkl= AFC of l^{th} record AFC, of K^{th} blood level, (Local Borana breed), jth year of birth, (1974 --- 2017),

μ = overall mean

Si = the fixed effect of i^{th} season of birth, (i = Long rainy, Short rainy and Dry seasons)

Bk=the effect of k^{th} breed group (k=Borana breed, and Holstein-Friesian-cross with, Borana)

eijkl = random residual error term breed for both centers,

Model. 3. For Reproductive traits CI, DO and NSP, At Holeta Debre Zeit, cross breed

Yijklm = μ + Si + Yrj + Gk + Pl + eijklm ………………………………………... 3

Where: -

Yijklm =m^{th} record of i^{th} group of periods of calving season of calving k^{th} genetic group and l^{th} parity (1,2,3,4,5,6,)

μ = overall mean

Yi = effect of i^{th} period of calving i = Long rainy, Short rainy and Dry seasons)

Sj = effect of j^{th} season of calving j = Long rainy, Short rainy and Dry seasons)

Gk = effect of k^{th} Genetic group (50 – 75% and 75% first generation and second generation)

Pl = effect of l^{th} parity of cow (1,2,3,4,5,6)

eijklm = random residual error term

Model. 4. For Reproductive traits CI, DO and NSPC, At Holeta and Debre Zeit Local Borana breed

Yijklm = μ + Si + Yrj + Gk + Pl + eijklm ………………………………………... 4

Where: -

Yijklm =m^{th} record of i^{th} group of periods of calving season of calving k^{th} genetic group and l^{th} parity

μ = overall mean

Yi = effect of i^{th} period of calving (i = Long rainy, Short rainy and Dry seasons)

Sj = effect of j^{th} season of calving (j = Long rainy, Short rainy and Dry seasons)

Gk = effect of k^{th} Genetic group (Local Borana cattle breeds)

Pl = effect of l^{th} parity of cow (1,2,3,4,5,6)

eijklm = random residual error term

Model. 5. For milk production traits (LMY, MY and LL) for Holeta and Debre Zeit cross breed

Yijklm = μ + Si + Yrj + Gk + Pl + eijklm ……………………………………….. 5

Where: -

Yijklm = LMY, MY, and LL of m^{th} cow in l^{th} breed group, k^{th} parity, j^{th} year of calving,

i^{th} season of calving (Long rainy, Short rainy and Dry seasons)
μ = overall mean

Si = the fixed effect of i^{th} season of calving (l = Long rainy, Short rainy and Dry seasons)
Yij = the effect of j^{th} year of calving (1982 -- 2020)

(Yij = the effect of j^{th} year of birth period, (1974 – 2017),
Jk = the effect of k^{th} parity (k = 1, 2, 3, 4, 5, and above $\geq$ 6)
Kl = the effect of l^{th} breed group (l = Holstein-Friesian with Borana crosses for both centers)

Eijklm = random residual error term

Model. 6.For milk production traits (LMY, MY and LL) for Holeta and Debre Zeit local Borana breed.

Yijklm = μ + Si + Yrj + Gk + Pl + eijklm ……………………………………….. 6

Where: -
Yijklm = LMY, MY, and LL of mth cow in lth breed group, kth parity, jth year of calving,

i^{th} season of calving (Long rainy, Short rainy and Dry seasons)

μ = overall mean

Si = the fixed effect of ith season of calving (Long rainy, Short rainy and Dry seasons)

(Yij = the effect of jth year of calving, (1982 --2020).

Yij = the effect of jth year of birth period, (1974 – 2017),

Jk = the effect of k^{th} parity (k = 1, 2, 3, 4, 5, and above ≥ 6)
Kl = the effect of l^{th} breed group (l = Holstein-Friesian with Borana crosses for both centers)

Eijklm = random residual error term

Model .7. Number of services per conception (NSPC)

Yijklmnz = μ + Si+ Dj + Yk+C l + P m + An +$e_{ijklmnz}$-........................... 7
Where:
$Y_{ijkllmnz}$ = the z^{th} record (NSPC) of i^{th} sire, j^{th} dam, k^{th} period of calving, l^{th} season of calving, m^{th} parity of the dam,
μ = overall mean
Si = the fixed effect of i^{th} sire breeds (i = Borana breed and, Holstein-Friesian, with Borana crosses bred for both centre)
Dj= the fixed effects of j^{th} dam (J=Borana breeds and Holstein-Friesian, with Borana crosses bred for both centre)

Jk = the fixed effect of k^{th} period of calving ($k_{= \text{period calving})}$ (1982 -- 2020, for Holeta cross. (1982 --2020. for Holeta local). (1992-- 2021.for Deber-Ziet cross (1991 – 2020. for Deber-Ziet local.

Kl= the fixed effect of l^{th} season of calving ((l=long rainy, short rainy and dry seasons for both centers)

lm= the effect of m^{th} parity (k = 1, 2, 3, 4, 5, and above ≥ 6)
Kl = the effect of l^{th} breed group (l = Holstein-Friesian with Borana crosses, and Local Borana breeds for both centers)

Eijklm = random residual error term

3.3.3. Genetic Parameters Estimation

Co-variance components and genetic parameters were estimated using the Average Information Restricted Maximum Likelihood (AI-REML) method fitting with a repeated model using WOMBAT software (Meyer, 2007) for all traits except for age at first calving, which was estimated by fitting a non-repeated multivariate model. The model used for the analysis of all traits except age at first calving was as follows:$y = \mathbf{X}\beta + \mathbf{Z}_{a}\alpha + \mathbf{Z}_{pe}pe + e$

Whereas the model used for the analysis of age at firs calving was, $y = X\beta + Z_{a}\alpha + Z_{m}m + e$ where y is a vector of observations on the considered traits; β, α, m, pe and e are vectors of fixed effects, direct additive genetic effects, maternal genetic effects, permanent environment effects and the residual effects, respectively.

Whereas **X**, $\mathbf{Z}_{a}$, $\mathbf{Z}_{m}$ and $\mathbf{Z}_{pe}$ are corresponding incidence matrices relating the fixed effect, direct additive genetic effects, maternal additive genetic effects and permanent environmental effects.

3.3.4. Estimation of breeding value and trends

Breeding values of animals for milk production and fertility traits were estimated from the Best Linear Unbiased Predictions (BLUP) solutions obtained from Wombat (Misztal et al., 2018). The least square means for annual breeding values will be calculated by the lm procedure of the R statistical package and deviations from the mean of the base year are considered as estimates of annual breeding value. Similarly, genetic trends of production and fertility traits were estimated with linear regression of the estimation of breeding value (EBV) as a function of the birth year of the animal.

4. RESULTS

4.1. Reproductive performance of cross bred dairy cattle

4.1.1. Age at first calving

The overall least-squares mean ± standard errors (SE) of age at first calving (AFC) of local breeds, 50% of blood level breeds and high grade crossbred dairy cows were 1171.62+39.40, 1103.49+ 29.42, and 1184.28+29.56- days, respectively with a coefficient of variation of 17.31% in both Holeta and Debre Zeit research center (Table. 9). Age at first calving was not different significantly (P>0.05) between the two research centers. The fixed effects of AFC such as calving year and genotype were highly significant (P < 0.001) while the birth season and dam parity was significant at P < 0.05. However, calving season was non-significant (P>0.05) in AFC (Table 9).

4.1.2. Calving interval (CI)

The overall average least-squares mean ± standard errors (SE) of CI of indigenous Borana cattle and their cross-bred, was 486.95 ± 1.81 with a coefficient of variation of 22.96% in both Holeta and Debre Zeit research centers (Table. 9). The average calving interval of dairy cattle in both research centres was 478.31 ± 7.69 for local, 472.85 ± 5.88 for 50%, 482.75 ± 5.85 for 50-75%, and 503.56 ± 5.77 for >75%, days respectively with the mean average CI of 486.39±5.83 days. Calving interval of cross-bred dairy cows with different exotic blood levels (50%, 50-75%, and >75%) in both research centres were highly significant (P < 0.001) for genotype, parity, calving years and location of the centers. The calving season is not significant (P>0.05) in both research centers for all breed types. This indicated that short calving intervals in both research centers which may be due to intensified management practice for these dairy animals.

4.1.3. Lactation length (LL)

The overall average least-squares mean ± standard errors (SE) of LL of indigenous Borana cattle and their cross-breds was 293.40 ± 1.15 with a coefficient of variation 25.86% in both Holeta and Debre Zeit research centers. The average lactation length of dairy cattle in both research centers was 204.43 ± 2.60 for local, 285.06 ± 2.32 for 50%, 282.5 ± 2.32 for 50%-75%, and 273.04 ± 2.19 days for >75%, respectively with the mean average LL of 280.2±2.28 days and 204.43± 2.60 days for locals and crossbred, respectively. Lactation length of cross-bred dairy cows with different exotic blood levels (50%, 50-75%, and >75%) in both research centres were highly significant (P < 0.001) for genotype, parity, calving years and location of the centres. The calving season is not significant (P>0.05) in both research centers for all breed types. This indicated that the shorter lactation length of dairy breeds in both research centers which may be due to intensified management practice for these dairy animals.

4.1.4. Lactation milk yield (LMY).

The overall average least-squares mean ± standard errors (SE) of lactation milk yield (LMY) of indigenous Borana cattle and their crossbred was 1948.57±13.73L with coefficient of variation 48.37% in both Holeta and Debre Zeit research center, respectively. The average lactation milk yields of dairy cattle in both research centers was 1424.32 ± 41.56 for local, 2334.08 ± 28.63 for 50%, 2354.08 ± 28.63 for 50%-75%, and 2108.32 ± 41.56 L for >75%, respectively with the mean average of was 2265.49±32.94 for crossbred and 1424.32 ± 41.5L for locals.

Lactation milk yields of cross-bred dairy cows with different exotic blood levels (50%, 50-75% and >75%) in both research centres, were highly significant (P < 0.001) for genotype, calving years and location of the centers whereas it was significant at P < 0.05 for calving season and parity. This indicated that better lactation milk yields of dairy breeds in both research centres which may be due to intensified management practice for these dairy animals that make the lactation milk yields higher than the other dairy farm's milk production.

4.1.5. Days open (DO) and number of services preconceptions (NSC)

The overall average least-squares mean ± standard errors (SE) ofdays open (DO) and number of services per conception (NSC) of indigenous Borana cattle and their cross-breds were 212.85 ± 128.3 for DO (days) and 1.6 ± 1.47 for NSC with coefficient of variation 16.22% and 1.4%, respectively in both Holeta and Debre Zeit research centres. The average days open and number of service preconceptions of dairy cattle in both research centres were 268±58.9 and 2.18±45.9 for local, 195±35.7 and 1.45±35.6 for 50%, 185± 43.3 and 1.25±55.4 for 50-75%, and 165 ± 38.7 and 1.22±45.4 for >75%, , respectively.

The variance of analysis for the factors of fixed effects (location of the centers, calving year, calving season) were not significant (P>0.05) on number of service preconceptions and location of the centers while calving year was significant on days open (P < 0.05). Parity and calving season were not significant (P>0.05) in number of days open. However, parity was significant (preconceptions (P < 0.01) in number of service preconceptions while genotype was highly significant (P < 0.001) in number of days open and number of services per conceptions.

4.2. Non-genetic Effects on Milk production traits

Parity - Parity has an effect on milk production in which the average production of milk was 1964.52 ± 28.21 L for 1st parity, 2079.54 ± 30.19 L for 2nd parity, 2020.82 ± 33.70 L for 3rd parity, 2038.65± 38.75 L for 4th parity, 1960.02± 44.95 L for 5th parity, 1950.26 ± 54.00 L for 6th parity and 1858.72± 66.23 for 7th parity. It showed that the parity of the dam, location of the farm (centeres), genotype and calving season had significant effects with the significance level of P < 0.01, P < 0.01, P < 0.001 and P < 0.05), respectively. The differences between parity three to six were not significant (P>0.05). However, after parity six, a declining trend was observed in the study results.

Season - Season of calving had a significant effect on TMY with the total milk yield of 1981.07 ± 28.31 L, 1977.15 ± 31.25 L, and 1908.61± 31.63 L for dry season, main rainy season, and short rainy season, respectively. . However, calving season had non-significant effect on lactation length with the average lactation length of 255.15± 2.15, 255.88 ± 2.39, 251.50 ± 2.40 (days) for dry season, main rainy season, and short rainy season, respectively.
Year - calving year had a highly significant effect (P < 0.001) on LMY. However, it has no significant (P>0.05) effect on LL in both research centers. Environmental variations, especially (heat stress in summer) coupled with fodder scarcity were the main reasons for low milk production.

4.3. Non-genetic Effects on reproduction traits

Year - Calving season had significant effect with the significant level of P < 0.001, P < 0.001 and P < 0.05 on CI, AFC and DO, respectively while the calving year of season has no-significant (P > 0.05) effect on NSC. The fertility traits appear to be caused by the combination of various environmental and management factors which start at calving, and have an effect on reproductive efficiency that shows that fertility traits have a high environmental component.

Parity - parity of dam had significant effect with the significant level of $P < 0.01$, $P < 0.001$ and $P < 0.001$ on number of services per conception (NSC), calving interval (CI) and age at first calving (AFC), respectively. Successful service or insemination depends on many factors such as quality of semen, skill of the inseminator, proper time of insemination and cows' condition-related factors. Management, nutrition and climate conditions may also affect the success of insemination. The effect of herds of cows also has significant effect ($P < 0.05$) on number of services per conception (SPC, DO and AFC) of Holstein Friesian dairy cattle. The lower values of NSC were found in cattle with three or more calving.

Location (agro-ecology) of the research centers - the location of the centres had highly significant ($P < 0.001$) on number of days open (Do), calving interval (CI) and age at first service (AFC). However, it has no significant ($P>0.05$) effect on the NSC. The combination of various environmental conditions and management factors affects the reproductive success of dairy cattle in these research centeres.

Genotype - the result of this study indicated that the genotype of herds had highly significant ($P < 0.001$) effect on days open (Do), number of services per conception (NSC), calving interval (CI) and age at first service (AFC). The combination of different genotype of herds, management aspects, nutrition, and climate conditions may also affect the success of reproductive dairy cattle**.**

Birth year - this study indicated that birth year had highly significant ($P < 0.05$) effect on DO, CI, NSC and AFC in both research centers. Calves born in the dry season tend to be younger at first service than those born in the short and long rainy season.

Other factors - season of birth and year of birth showed significant ($p< 0.001$) effect on age at first calving (AFC) service preconception (NSC); days open (DO) and calving interval (CI) of dairy cattle.

Table 9. Least-squares mean ± standard errors (SE) of productive and reproductive performance of local and crossbred dairy cows at Holeta and Debre Zeit agricultural Research enter.

Fixed effect	**n**	**TMY (Litter)**	**LL (Day)**	**Fixed effect**	**N**	**DO (day)**	**NSC**	**n**	**CI (Days)**	**n**	**AFC (Day)**
Overall mean	5809	1948.57 ± 13.73	293.40 ± 1.15	Overall mean	3545	212.85 ± 128.3	1.6 ± 1.47	4536	486.95 ± 1.81	1169	1260.49 ± 8.15
CV (%)		48.37	25.86	CV (%)		16.22	1.3		22.96		17.31
Range		100 - 7352.20	100 - 600	Range		300- 545	240-484		302 - 972		642 - 2156
Genotype		***	***	Genotype		***	***		***		***
Local	719	1424.32 ± 41.56c	204.43 ± 2.60c	Local	804	268±58.9c	2.18	901	478.31 ± 7.69b	114	1171.62 ± 39.40a
50% crossbred	2369	2334.08 ± 28.63a	285.06 ± 2.32a	50% crossbred	1568	195±35.7a	1.45	1815	472.85 ± 5.88b	324	1103.49 ± 29.42b
50-75%, crossbred	1285	2354.06 ± 28.63a	282.5 ± 2.32a	50-75%, crossbred	1128	185 ± 43.3b	1.35	1178	482.75 ± 5.85b	516	1173.49 ± 29.42b
High grade crossbred	2721	2108.32 ± 41.56b	273.04 ± 2.19b	High grade crossbred	1634	165 ± 38.7b	1.45	1820	503.56 ± 5.77a	731	1184.28± 29.56a
center		***	***	center		*	ns		***		*
Debre Zeit	1090	2330.35 ± 35.99a	219.80 ± 2.84b	Debre Zeit	688	182±28.6b	1.38	878	516.62 ± 6.91a	338	1112.04 ± 34.12b
Holeta	4719	1580.88± 22.99b	288.55 ± 1.60a	Holeta	2568	178±38.7b	1.36	3658	453.18 ± 5.47b	831	1147.55± 28.01a
Calving season		*	Ns	Birth season		ns	ns		ns		ns
Dry	2691	1981.07 ± 28.31a	255.15± 2.15	Dry	2255	234±48.5c	1.58	2375	488.61 ± 5.81	516	1115.34± 31.10
Main rainy	1507	1977.15 ± 31.25ab	255.88 ± 2.39	Main rainy	1028	218±28.6b	1.46	1052	484.55± 6.23	348	1142.83 ± 31.25

Short rainy	1609	1908.61± 31.63b	251.50± 2.40	Short rainy	1085	205±38.7b	1.82	1109	481.56± 6.16	305	1131.22 ± 31.53
Dam parity		*	***	Dam parity		ns	**		***		**
1	1574	1964.52 ± 28.21a	279.75 ± 2.20a	1	248	220	1.71	308	509.06 ± 8.27ab	1056	1227.87 ± 10.44a
2	1262	2079.54 ± 30.19b	276.14 ± 2.36a	2	836	218	1.38	1214	521.94 ± 5.79a	36	1195.45 ± 42.48ab
3	967	2020.82 ± 33.70ab	264.40 ± 2.65b	3	876	202	1.64	940	504.31± 6.28b	26	1137.02 ± 48.75ab
4	709	2038.65± 38.75a	259.05± 3.03b	4	578	180	1.83	695	483.19± 6.80bc	24	1151.65± 51.99ab
5	503	1960.02± 44.95ab	253.74 ± 3.46bc	5	464	164	1.46	514	481.25 ± 7.45bc	19	1004.36 ± 61.04b
6	339	1950.26 ± 54.00ab	251.88 ± 3.99bc	6	258	145	1.38	369	470.64 ± 8.23c	8	1062.43± 85.51ab
7	220	1858.72± 66.23ab	235.07 ± 4.85c	7	135	128	1.53	235	472.66 ± 9.64c		
8	117	1899.16± 90.03ab	234.60± 6.61c	8	120	116	1.28	131	465.39± 11.75c		
>9	118	1828.85± 90.77ab	232.96± 7.36c	>9	115	84	1.44	130	455.70 ± 11.65c		
Calving Year	5809	***	***	Birth Year	3428	*	ns	4536	***	1169	***

Means with the same superscript are not statistically different at P = 0.05; ns: not significant; ***P < 0.001; **P < 0.01; * P < 0.05; TMY: total milk yield; LL: lactation length; DO; days open; NSC; Number of preconceptions; CI: calving interval; AFC: age at first calving.

4.4. Heritability and Repeatability

The direct heritability and repeatability estimates for production and reproduction traits are given in Table 9. The direct heritability of AFC for the dairy herd maintained at Holeta Agricultural Research Center (HARC) was 0.393. The low direct heritability values indicated that the traits will be improved through good management practice for the herd rather than genetic improvement whereas relatively moderate heritability values indicated that the trait could be improved by genetic improvement rather than management practice. Hence, CI and LL are less likely to be improved by the genetic improvement of the herd whereas TMY and AFC could be improved by good herd management procedures in the herd at Holeta Agricultural Research center. The repeatability values for the traits analysed ranged from 0.121 (CI) to 0.434 (TMY) for the dairy herd maintained at Holeta Agricultural Research Center (HARC) (Table 9).

The phenotypic correlation among the pairs of traits investigated ranged from 0.022 (LL and AFC) to 0.931 (TMY and LL) (Table 10). Similarly, the genetic correlation ranged from 0.030 (LL and AFC) to 0.494 (TMY and LL). On the other hand, the environmental correlations ranged from -0.009 (CI and AFC) to 0.504 (TMY and LL). In this study, the results was indicates that dairy cattle phenotypic, genetic and environmental correlations in between TMY and LL were highest. Improving environmental conditions for one trait will work against to the other traits. The genetic correlation values indicated that pairs of traits including TMY and CI, TMY and LL, CI and LL are affected by same genes.

Table.10. Direct heritability and repeatability estimates for production and reproduction traits for dairy herd maintained at Holeta Agricultural research centre

Trait	TMY	CI	LL	AFC
h^2_a	0.326±1.00	0.043±0.021	0.104±0.019	0.393±0.091
h^2_m	---------	--------	-------	0.070±0.087
pe^2	0.108±	0.079±0.024	0.074±0.020	---------
R	0.434	0.121	0.178	--------
σ^2_a	289960	755.017	722.710	21.761
σ^2_m	-------	-------	-------	3.901
σ^2_{pe}	95704.40	1389.98	519.586	
σ^2_e	491034	14914.10	5734.62	29.732
σ^2_P	888264	17679.60	6976.92	55.394

h^2_a: direct heritability; h^2_m: maternal heritability; Pe^2: ratio of permanent environmental variance to phenotypic variance; r: repeatability; σ^2_a: additive variance; σ^2_m: maternal variance; σ^2_{pe}: permanent environmental variance; σ^2_e: residual variance; σ^2_P: phenotypic variance; TMY: total milk yield; CI: calving interval; LL: lactation length; AFC: age at first calving.

Table 11.correlation estimates among total milk yield and reproduction traits for production and reproduction traits for dairy herd maintained at Holeta Agricultural research centre

Trait 1	Trait 2	r_{d12}	r_{e12}	r_{p12}
TMY	CI	0.732±0.168	0.179±0.020	0.209±0.017
TMY	LL	0.931±0.043	0.494±0.013	0.504±0.010
TMY	AFC	0.053±0.091	0.130±0.062	0.090±0.037
CI	LL	0.894±0.159	0.412±0.017	0.403±0.015
CI	AFC	0.293±0.205	0.822+0.014	-0.009+0.038
LL	AFC	0.022±0.128	0.030±0.056	0.025±0.037

r_{p12}: phenotypic correlation between trait 1 and trait 2; r_{d12}: direct genetic correlations between traits 1and 2; r_{e12}: environmental correlation between trait 1 and 2; TMY: total milk yield; CI: calving interval; LL: lactation length; AFC: age at first calving.

The direct heritability and repeatability estimates for production and reproduction traits are given in Table 11 for the dairy herd maintained at Debre Zeit Agricultural Research Center (DZARC). The direct heritability ranged from 0.003 (CI) to 0.293 (AFC) for the dairy herd maintained at DZARC. The low direct heritability values indicated that the traits shall be improved through good husbandry management practices to the herd than genetic improvement practice whereas relatively moderate heritability values indicated that the trait could be improved by the genetic improvement than the herd management practice. Hence, CI and LL are less likely to be improved by the genetic improvement of the herd whereas TMY and AFC could be improved through selection aspects at DZARC.

The repeatability values for the traits analyzed ranged from 0.133 (CI) to 0.244 (TMY) for dairy herd maintained at DZRC (Table 10). The phenotypic correlation among the pairs of traits investigated on this study was 0.012 for LL and AFC, and 0.831 for TMY and LL (Table 11). Similarly, the genetic correlation was 0.012 for LL and AFC, and 0.884 for CI and AFC. On the other hand, the environmental correlations of this study were -0.019 for CI and AFC, and 0.504 for TMY and LL. All the phenotypic, genetic and environmental correlations between TMY and LL were the highest. This was true because high phenotypic correlation between TMY and LL means all factors affecting both traits are same. The negative environmental correlations between CI and AFC indicated that both traits are affected by different environmental factors. The genetic correlation values indicated that pairs of traits including TMY and CI, TMY and LL, CI and LL are affected by same genes. Hence, improving one of the traits may lead to the improvement to the other trait.

Table. 12. Direct heritability and repeatability estimates for production and reproduction traits for dairy herd maintained at Debre Zeit Agricultural Research Center

Trait	TMY	CI	LL	AFL
h^2_a	0.236±0.015	0.003±0.012	0.114±0.01	0.293±0.061
h^2_m	-----	-------	--------	0.062±0.083
pe^2	0.099±	0.081±0.024	0.047±0.020	---
R	0.244	0.133	0.144	------
σ^2_a	389950	855.03	923.810	50.167
σ^2_m	-----	------	-------	4.501
σ^2_{pe}	85703.30	2387.89	420.865	
σ^2_e	291033	34915.10	4734.61	19.730
σ^2_P	788265	16680.61	7077.90	45.495

h^2_a: direct heritability; h^2_m: maternal heritability; Pe^2: ratio of permanent environmental variance to phenotypic variance; r: repeatability; σ^2_a: additive variance; σ^2_m: maternal variance; σ^2_{pe}: permanent environmental variance; σ^2_e: residual variance; σ^2_P; phenotypic variance; TMY: total milk yield; CI: calving interval; LL: lactation length; AFL: age at first calving.

Table 13. Correlation estimates among production and reproduction traits for production and reproduction traits for dairy herd maintained at Debre Zeit Agricultural Research Center

Trait 1	Trait 2	rd12	re12	rp12
TMY	CI	0.632±0.169	0.189±0.020	0.219±0.016
TMY	LL	0.831±0.044	0.454±0.013	0.534±0.09
TMY	AFC	0.043±0.092	0.120±0.062	0.070±0.036
CI	LL	0.794±0.160	0.432±0.017	0.423±0.014
CI	AFC	0.193±0.206	0.882+0.014	-0.019+0.037
LL	AFC	0.012±0.126	0.050±0.056	0.035±0.038

rp12: phenotypic correlation between trait 1 and trait 2; *rd12*: direct genetic correlations between traits 1and 2; *re12*: environmental correlation between trait 1 and 2; TMY: total milk yield; CI: calving interval; LL: lactation length; AFC: age at first calving.

4.3. Breeding values and trends

The trends of estimated breeding values are given in figures 1 and 2 for the production and reproduction traits of herds maintained at HARC. Figure 1 indicates the trends of estimated breeding value for CI and LL for the dairy herd maintained at HARC whereas figure 2 indicated the trends for estimated breeding value of lactation milk yield for the same herd. In similar fashion, the trends of LMY, CI, LL and AFC are given in Figures 3, 4, 5 and 6, respectively for the dairy herd maintained at DZARC. None of the trends of estimated breeding value showed a progressing pattern by the years. At both centers, genetic progress was not observed on neither of the studied traits shows progressing pattern.

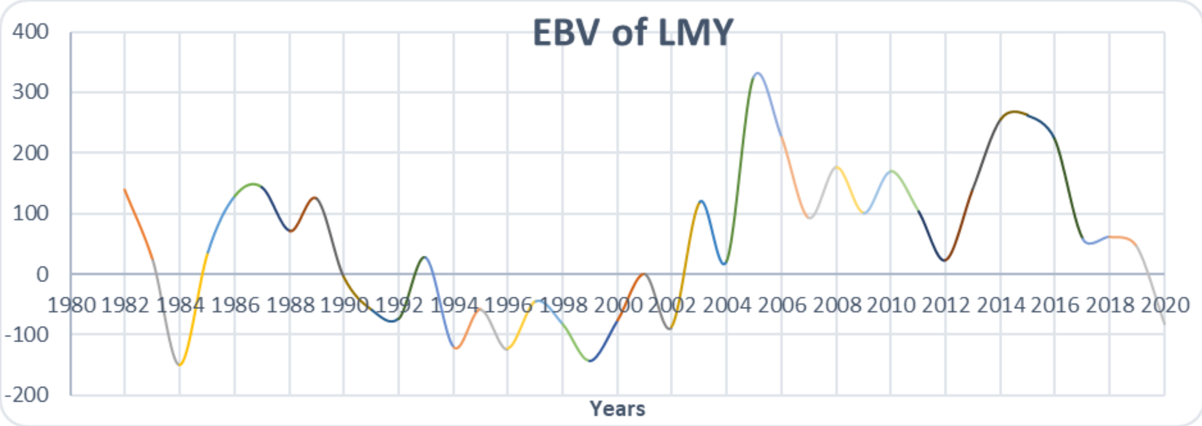


Figure 1.Trends of estimated breeding values of lactation milk yield of dairy cattle herd maintained at Holeta Agricultural Research Center.

As observed on figure 1 above, the estimated breeding value for LMY has increasing and decreasing trends throughout the production years in which data used for this study program. There was a decreasing trend from 1981 to 1983 and from 1990 to 2002 whereas there was an increasing trend from 1984 to 1989 and from 2002 to 2019. This show that farms used different sires which has different performance which in turn resulted fluctuation in milk production.

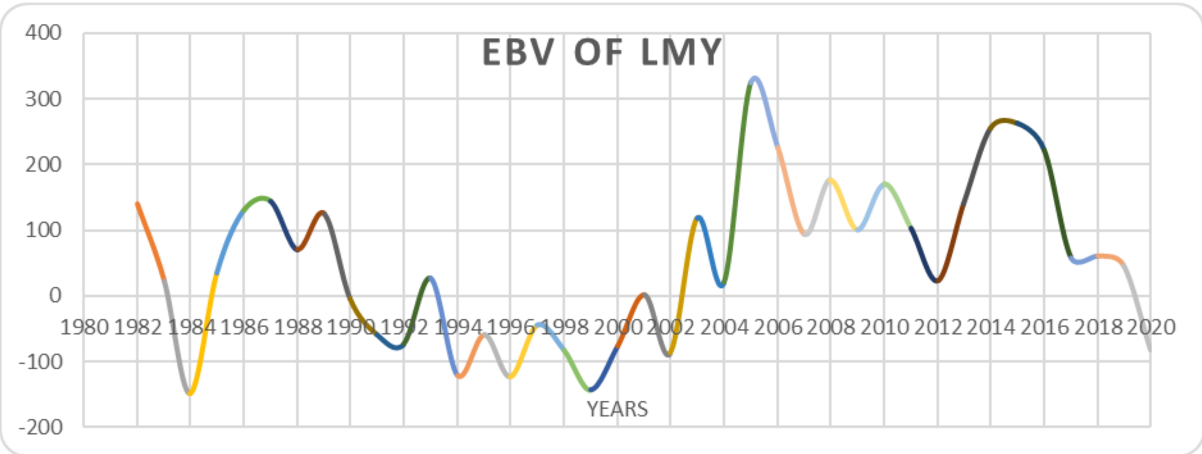


Figure 2.Trends in estimated breeding values of calving interval, lactation length and age at first calving of dairy cattle maintained at Holeta Agricultural research Center

Estimation of breeding value for LMY indicated in figure 2. The results showed that there were a decreasing trend from 1983 to 1984, 1990 to1992, and 1993 to 2002 whereas there was an increasing trend from 1984 to 1989 and from 2002 to 2020. This shows that Holeta research center used different sires for breeding purpose which has different potential of breeding values

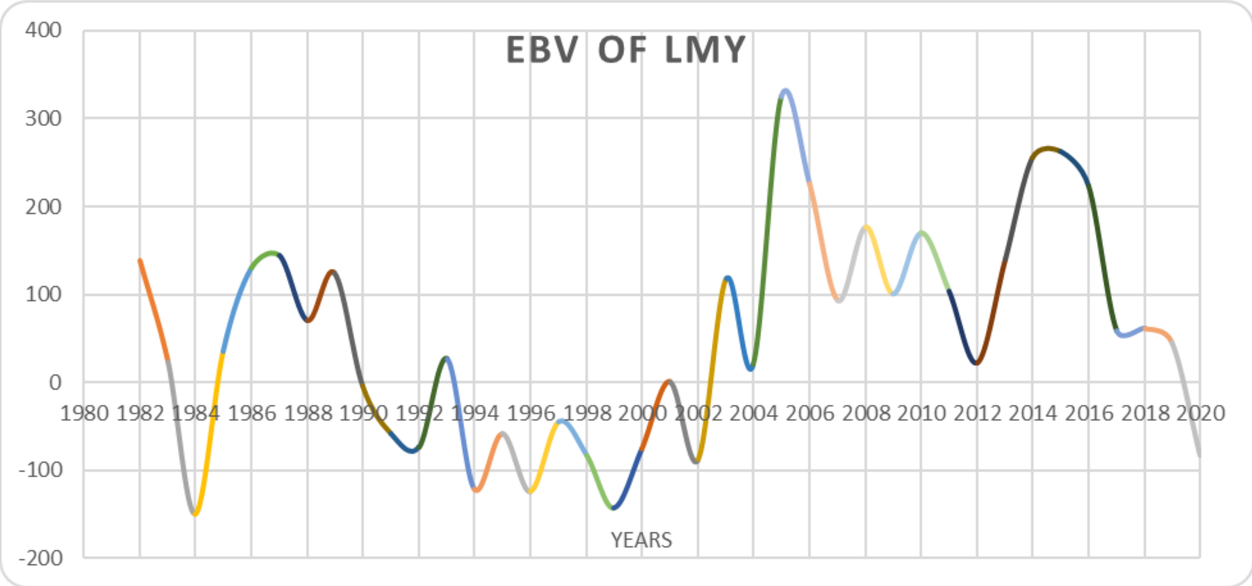


Figure 3. Trends of Estimated breeding values of lactation milk yield of dairy cattle herd maintained at Deber Ziet Agricultural Research Center.

Estimation of breeding value of LMY at Debre Zeit research centre which indicated in figure 3. The result showed that there were increasing trend from 1984 to 1989, 1992 to 1993, 2002 to 2020 and decreasing trends from 1990 to 1992 and 1993 to 2001. This show that Debre Zeit research centre used different sires for breeding purpose which has different potential of breeding values.

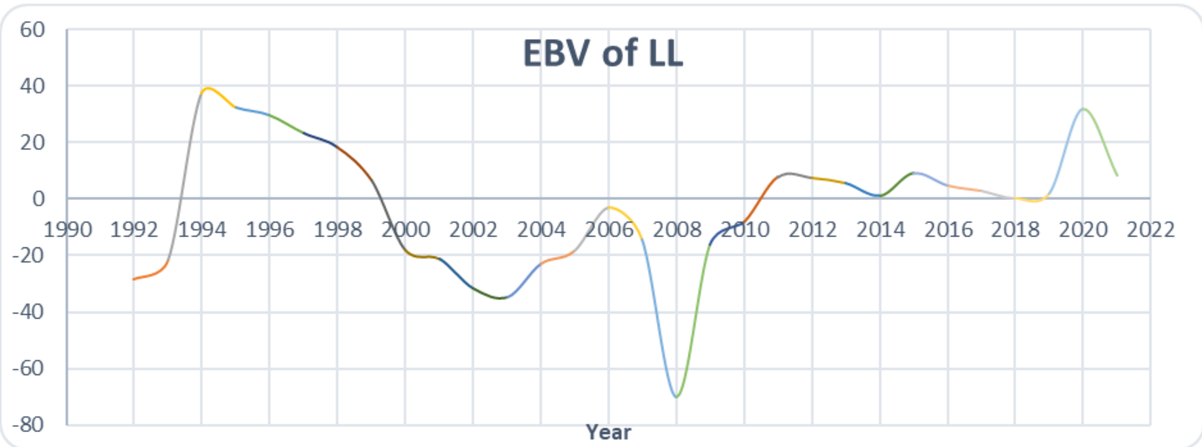


Figure 4.Trends of estimated breeding values of lactation length of dairy cattle herd maintained at Debre Zeit Agricultural Research Center

Estimation of breeding value on LL at Debre Zeit research centre is indicated in Figure 4. The result showed that there were increasing trend from 1993 to 1999 and 2010 to 2021, and decreasing trends from 2000 to 2009. This show that Debre Zeit research centre used different sires for breeding purpose which has different potential of breeding values.

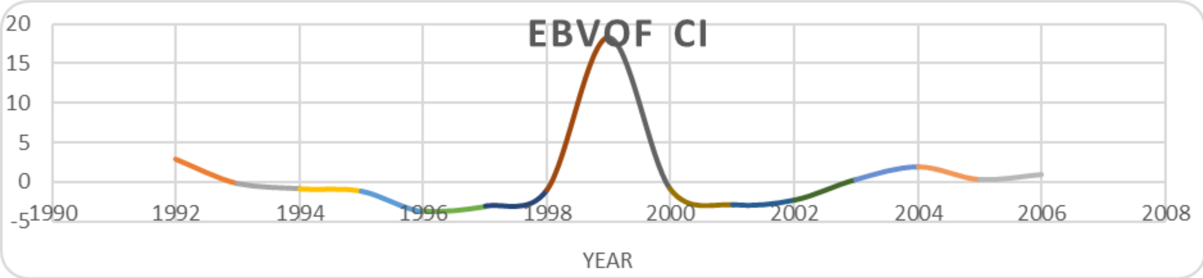
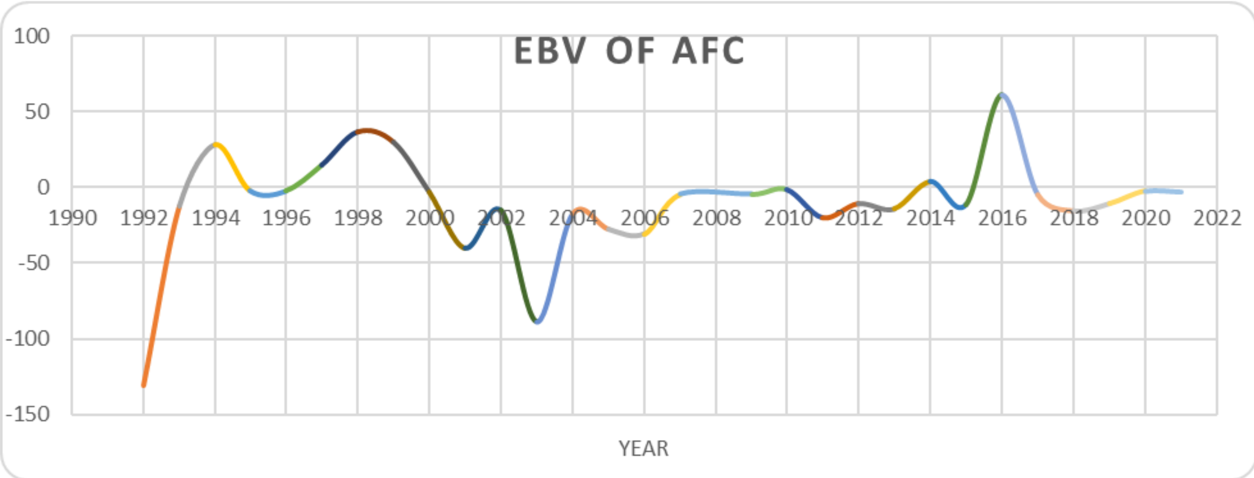


Figure. 5. Trends of Estimated breeding values of CI of dairy cattle herd maintained at Debre Zeit Agricultural Research Center.

Estimation of breeding value on CI at Debre Zeit research centre is indicated in Figure 5. The result showed that there were increasing trend from 1998 to 1999 and 2003 to 2006, and decreasing trend from 1992 to 1998 and 2000 to 2001. This show that the farm used different sires for breeding purpose which has different potential of breeding values



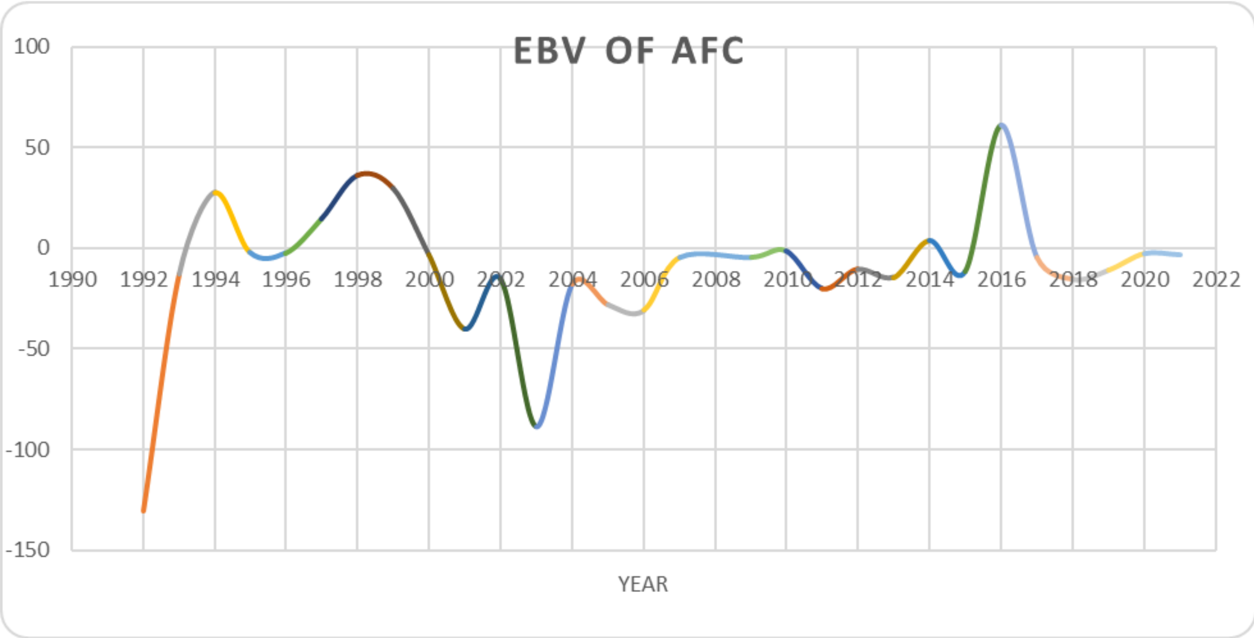


Figure 6. Trends of Estimated breeding values of age at first calving of dairy cattle herd maintained at Debre Zeit Agricultural Research Center.

Estimation of breeding value for AFC at Debre Zeit research centre is indicated in Figure 6. The result showed that there were increasing trend from 1993 to 1995, 1996 to 1999 and 2015 to 2017, and decreasing trend from 1995 to 1996, 2000 to 2014 and 2018 to 2021. This shows that the farm used different sires for breeding purpose which has different potential of breeding values.

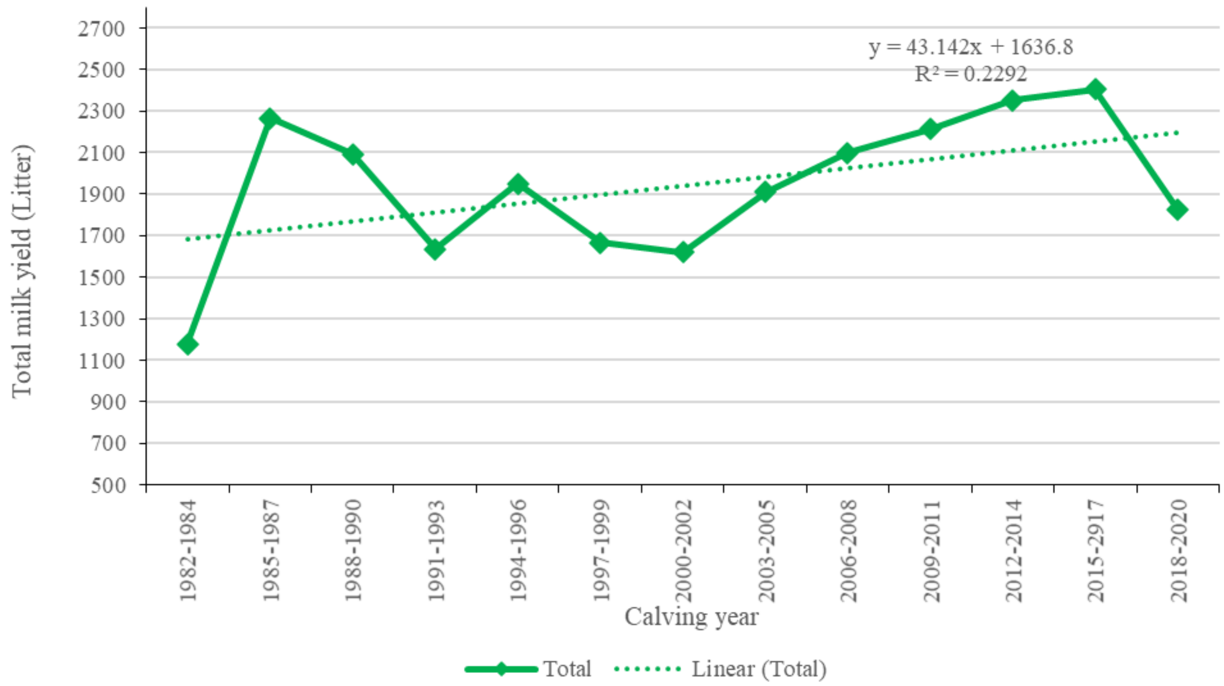


Figure 7.Total milk yield trends.

The estimation of total milk yield in both research centres are shown in Figure 7. There were increasing trend from 1984 to 1991, 1995 to 1996 and 2006 to 2015, and decreasing trends from 1992 to 1995, 1997 to 2007 and 2018 to 2020. This productivity fluctuation might be due to the effects of climatic conditions, reduction of nutritional status, husbandry management practice, and an unplanned breeding system in the research centres.

To achieve the farm's ultimate profitability goal, the center must keep the optimal feeding and management conditions to reduce heat stress. Nutritional management programs such as total mixed rations (TMR), low quantity with high quality nutrition and lead to high quality fibre rations and rations supplemented with necessary amino acids lead to productivity, and ultimately increase profits for dairy operations.

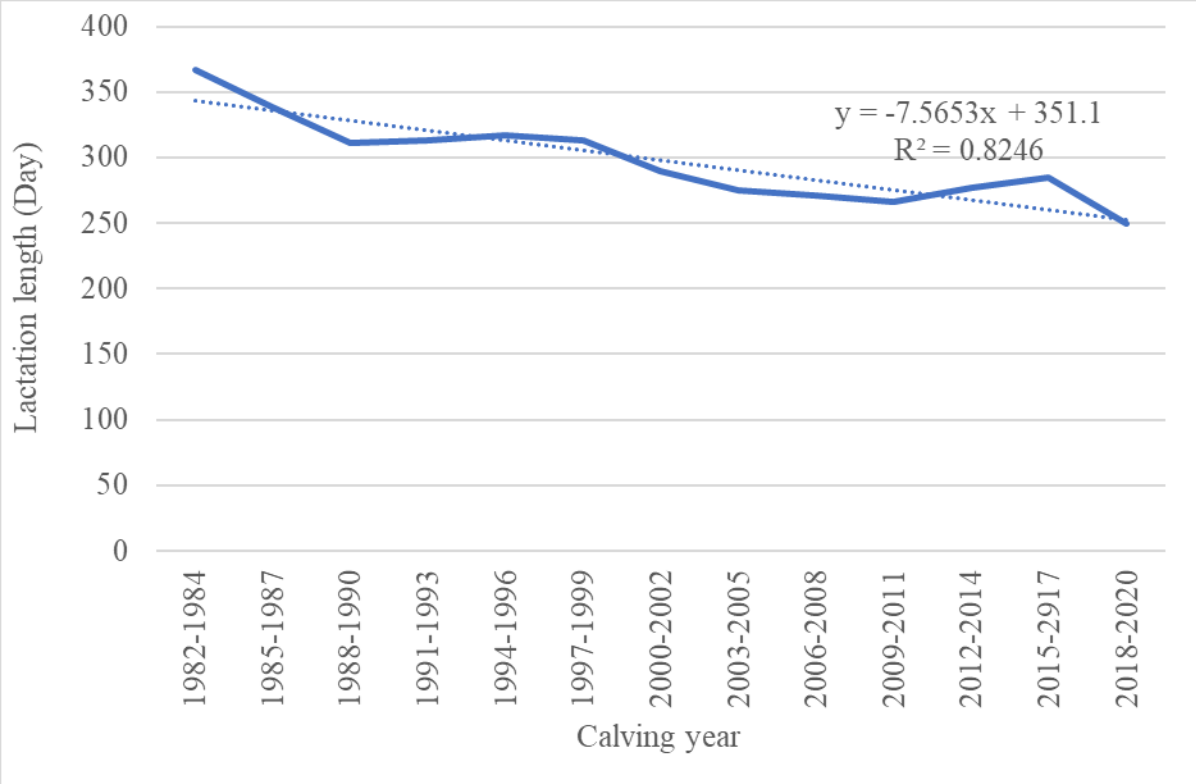


Figure 8. Phenotypic lactation length trend by calving year

The estimation of phenotypic lactation length in both research centres are in Figure 8. The result showed that there was an increased trend from 1993 to 2001, 2011 to 2018, and then decline gradually from 1884 to 1992, 2002 to 2010 and 2019 to 2020. These results were indicated that the effects environmental condition which enforced dairy animals to reduce their productivity and productive performance through reduction of nutritional status, husbandry management practice, and unplanned breeding system in the research centres.

It may be the results of climatic conditions, reduction of nutritional status, husbandry management practice, and unplanned breeding system leads to inappropriate LL with productivities and reproduction condition in the farm. To achieve the farm ultimate profitability with appropriate reproductive, the farm must be kept in the optimal feeding and management conditions to reduce heat stress, nutritional management programs such as total mixed rations (TMR), low quantity-high quality fibre rations and rations supplemented with necessary amino acids leads to productivity and ultimately become increasing profits for dairy operations constantly.

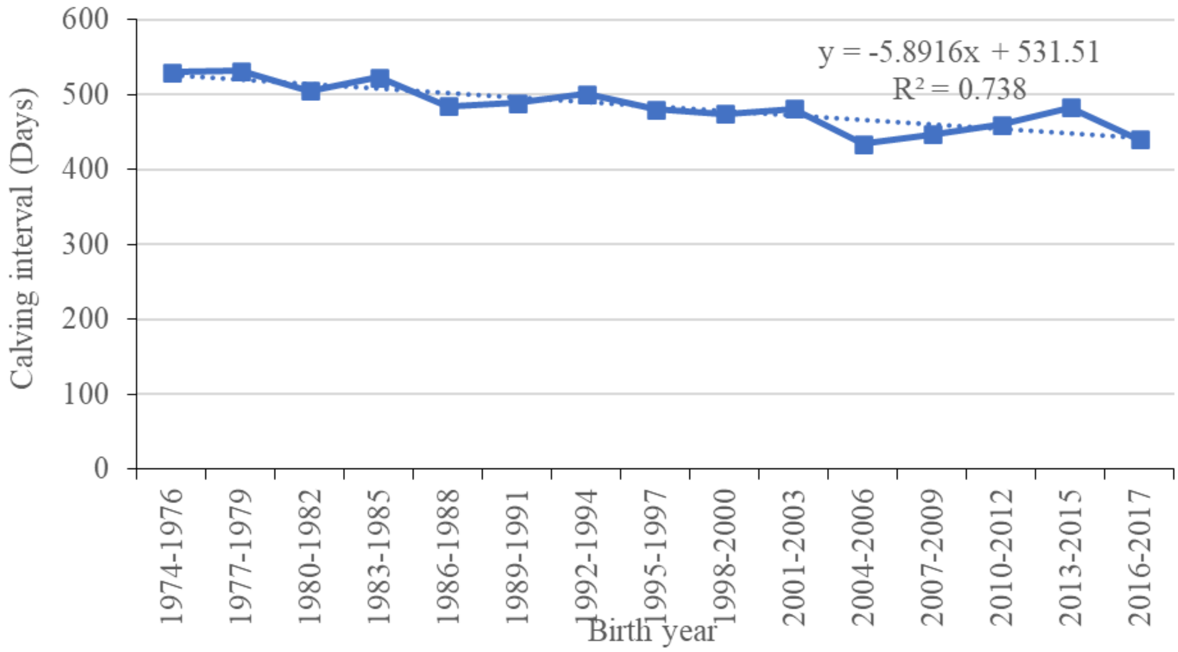


Figure 9. Phenotypic calving interval trend by birth year

Figure 9 - indicated that the result of CI from 1974 to 2003, 2006 to 2015 slightly declined to straight line which is not highly fluctuated which indicated the better management practice in the farms during the indicated time. Calving interval from 2004 to 2006 and 2016 to 2017 showed decreasing conditions which indicated miss management practice. at this time In general, a good husbandry practice in the farm was crucial which leads dairy farms to the ultimate profitability, economical sustainability, as well as busting cross breed dairy cattle productivities and reproductivities in the farms.

Maximum the rates of breeding efficiency in any farms, cross bred dairy cattle are attained through regular calving of one viable offspring per breeding cow in the herd in a year. To achieve this goal, reproductive technologies have been developed in generations over the years. Reproductive biotechnologies intend to be used routinely to shorten generational intervals and to propagate genetic material among breeding animal populations. These techniques are together all face today a strong wave of increasing dairy production by the use of artificial insemination (AI) and the use of hormone as means oestrus synchronization.

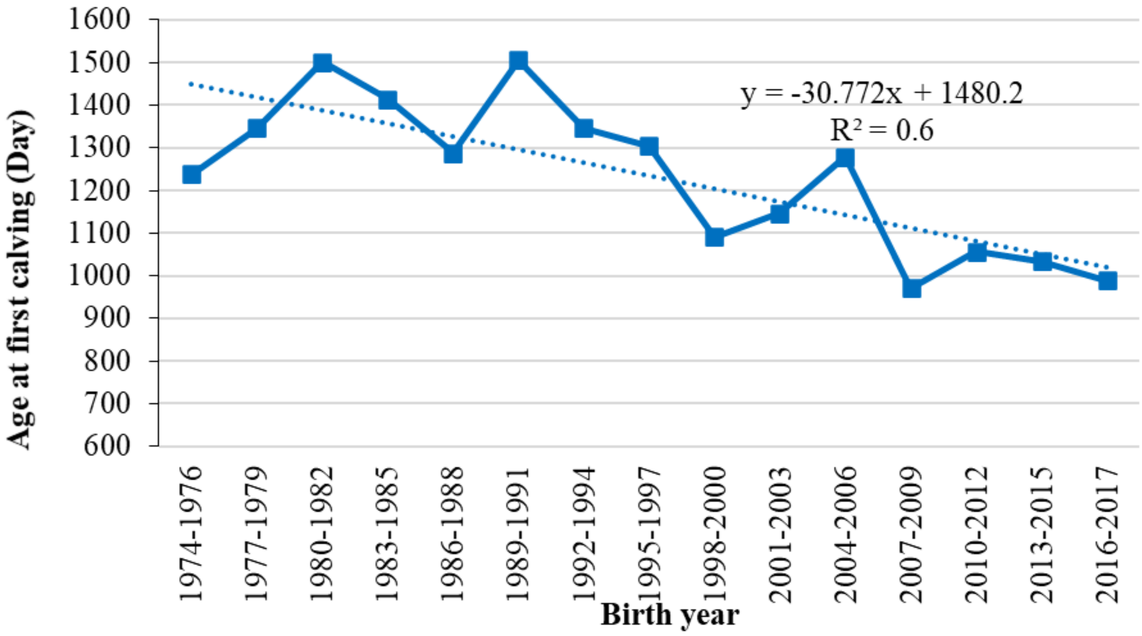


Figure 10. Phenotypic age at first calving trend by birth year

The estimation of phenotypic age at first calving in both research centres are shown in Figure 10. The result showed that the age at first calving showed increasing trend from 1974 to 1985, 1988 to 1997 and 2003 to 2006, and decreasing trends from 1985 to 1988, 1997 to 2003, and 2012 to 2017. This indicated that year of birth has varied through season and management level. This might be due to relatively good management practice through different ways such as feeding, housing, breeding, improved forage development and feed conservation and health care.

5. DISCUSSIONS

5.1. Lactation milk yields (LMY)

The results of this study for both research centeres of indigenes Borana cattle and their crossbred was greater than the result reported by Niraj et al. (2014). It is also greater than the value reported by Belay et al. (2012) who found a mean lactation milk yield of 1768.15 ± 15.28 and 1293.01 ± 23.70 for Horro x HF and Horro x Jersey cross, respectively at Bako research center. This indicated that better lactation milk yields of dairy breeds in both research centers, which may be due to intensified management practice for these dairy animals that makes the lactation milk yields higher than other dairy farms. Million and Tadelle (2003) found that crossbreeds of Borana X HF of 50%, 75% and 87.5% have lactation milk yield of 1740, 2044 and 1902 L, respectively indicating as exotic blood levels increases, all reproductive and productive trait performance of crossbred also increased up to 75% exotic blood level, and then it shows turn down.

The non-significant effect of location of the research centers in the current study is agreed with the finding of Million and Tadelle (2003) might be due to similar management system such as health condition and feeding status in the farm. Improving environmental conditions and management practices compiled with improved genetic potential of dairy animals would be a more effective method for high milk production (Million et al., 2010)

5.1.1. Lactation Length (LL)

The average lactation length of dairy cattle in both research centers is comparable with the average lactation length of 291.86± 6.55, 278.4± 90.17 and 252.25±5.31 reported by Javed et al. (2004); Sattar et al. (2005) and Haftu Kebede (2015), respectively for cross breed dairy cows. Higher lactation length of 478.67±4.61, 497.08±3.69, 475.48±4.08 and 476.35±3.91 were reported by Besufekad (2008); Direba (2012); Wassie et al. (201 5) and Kefale et al. (2019), respectively. Lactation length of indigenous cattle increased as exotic blood level increases because of its genetic makeup. However, even though there was an increment trend in lactation length as blood level increased, they could not reach generally accepted 305 days of lactation length for crossbred; this might be due to the reason of poor nutritional status, poor breeding management, diseases and poor management practices.

5.1.2. Calving interval (CI)

The average calving interval of dairy cattle in both research centers is in agreement with the average calving interval (days) 477.9, 486.9, 497.08±3.69, 476.36 ±4.73 and 476.35±3.91 reported by Besufekad (2008), Suhail *et al.* (2010); Direba (2012); Wassie *et al*. (2015); Kefale *et al*. (2019), respectively.,. The current result of CI for local dairy cows was less than the results reported by Mulugeta and Belayeneh (2013). This might be indicative of good husbandry practice for cross bred management under both research centers, in breed handling, breeding managements, accesses of artificial insemination service, or natural bull service, which make shorter days open, disease control and good experience of both research centeres on all dairy farm management practices. However the CI of local borana breeds in the current study is greater than the results (453 and 473) found by Demeke et al. (2004) and Niraj *et al*. (2014), respectively. Longer CI is mainly attributed to the results of longer DO obtain from the current result on local breed study which could be related to environmental factors such as miss management practice, non-follow up to detect heat, in adequate plan of nutrition and poor health condition. Relatively longer calving interval might be an indication of poor nutritional status, poor breeding management, lack of own bull for natural service, artificial insemination, longer days open, disease and poor management practice (Belay et al., 2012).

5.1.3. Age at first calving (AFC)

Age at first calving (AFC) in the current study is nearly comparable with the AFC of 1188 and 1184.7 days reported by Million *et al*. (2010) and Wassie *et al*. (2015), respectively for cross dairy cattle. 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 consequence on dairy cattle generation, calf crop and milk production. Dietary supplementation of heifers during their growth period reported a decrease from birth to age at first service for the interval and age at first calving, early maturing females are known to have a relatively long and fruitful reproductive life and thus it determines the rate of genetic progress and population growth rate (Hammoud *et al.*, 2010).

5.1.4. Days open (DO)

DO of indigenes Borana cattle and their crossbred of, local, 50%, 50-75% and >75% exotic blood level were 212.85 ± 128.3 DO (days) in both Holeta and Debre Zeit research center, respectively. The average days open, of dairy cattle in both research centers for local 268±58.9, 50% 195±35.7a, 50-75%, 185± 43.3b, and >75%, 165 ± 38.7, respectively. The average days open in the current study is comparable with the results of 169.17±.3 days for 75% Friesian, 155 days for Zebu X Holstein Friesian, 184.72±2.3 days for HFX Borana, 195.47 ± 4.74 days for HFX Borana and 197.10±3.88. days reported by Kefena *et al*. (2006a); Mulindwa et al. (2006); Amasaib et al. (2008); Addisu et al. (2010) and million et al. (2010), respectively. Days open was influenced by season, cows calving during short rainy season has shown short days open compared to cows calving during dry and main rainy season. This might be due to variation of feeding regime across the seasons particularly scarcity of feed resource in the grazing areas and variation of concentrate supplementation.

5.1.5. Number of service preconception (NSC)

This result of NSC in the current study is comparable with the result (2.2 and 2.17) reported by Niraj et al. (2014) and Meseret et al. (2014), respectively. However, it is lower than the result (1.81 for HF, 2.02±0.02 for Jersey, 1.75 ± 0.03 for HF x Borana) reported by Million et al. (2010); Direba et al. (2015) and Kefale et al. (2019), respectively. This indicated that there is excellent herd management and performance of cows which can be associated with lower services per conception, which might be due to the consistent management such as feeding, heat detection, skill of inseminator, time of insemination, semen quality, animal health condition and other husbandry practice in the research centres.

6. CONCLUSION AND RECOMMENDATION

6.1. Conclusion

This study was only designed for estimation of genetic and non-genetic parameters for productive and reproductive traits of cross-bred dairy cattle at Holeta and Deber zeite agriculture research centers with different herd groups. The long-term data used for both HARC & DZARC data was about 27,286 pure Borana and their cross-breds which were maintained in both research centers. The milk yield found in this study was moderate in both dairy farmers' research. The mean average LMY was 2265.49±32.94 for crossbreds, and 1424.32 ± 41.56 for locals. However, the milk production performance of locals and HFX with Borana breeds on the study farm was not satisfactory and below the standard which was not expected from modern dairy research farms. Almost non-genetic factors have significant effects ($P < 0.05$) on total milk yield (TMY) and lactation length in both farms' centers except calving season which has no significant effects on lactation length (LL). The calving year has no significant effect on NSPC, lactation length and calving season. Animals with high grade animal inheritance had better potential for lactation performance and bred earlier than low grade animal breeds (< 75%) inheritance. These results indicated that better lactation milk yields of dairy breeds in both research centers which may be due to intensified management practice for these dairy animals that makes the lactation milk yields show the chances to improve in the future more efficiently than the other dairy farms for milk production.

The fertility traits appear to be caused by the combination of various environmental and management factors, which start at calving, and all have an effect on reproductive efficiency. This shows that fertility traits have a high environmental component, which implies that genetic improvement through selection is likely to be a slow process. Successful service or insemination depends on many factors such as quality of semen, skill of the inseminator, proper time of insemination and cows' condition, and related factors. Management, nutrition and climate conditions may also affect the success of insemination.

The effect of herds of cows was significant on service per conception (NSC, DO and AFC), of Holstein Friesian dairy cattle. The number and season of calving has significantly affected the (NSC) of cross-bred cows. The lower values of NSC were found. The results of this indicated the herd efficiency of inseminators, quality of semen, good herd management practice, and animals keeping healthy in good conditions.

The mean obtained for LL is promising and falls within the normal range that is expected from modern dairy farmers. The calving season is not significant in both research centers for all breed types. This indicated that the shorter lactation length of dairy breeds in both research centeres, which may be due to intensified management practice for these dairy animals, makes the lactation length shorter than on the other dairy farms. This indicates that these research farms have more opportunities to improve dairy cattle production and express what could be initiated the dairy cattle to express their genetic potential.

6.2.Recommendation

Based on the above conclusion, the following recommendations were forwarded.

- The productive and reproductive performance of dairy cattle breeds in both research centeres has lower values. When compared to others, authors find results in different tropical countries.
- As the parity increases beyond parity, 6, LMY and LL of HF X Borana crossbred dairy cows decreased, it should be needed decrease after parity 6.
- These lower values may be due to environmental factors, like proper feeding, on time heat detection, proper time insemination, periods of supply quantity and quality feed, controlling disease outbreaks…etc.
- Improve the productive and reproductive performance of dairy cattle through intensified management, practice, like improving nutrition, health care, right time insemination, and using new reproductive technology
- Applying standard record keeping on reproductive and productive traits should be necessary.
- Management should focus on postpartum reproductive problems, farm record keeping and using selected breeding bulls.

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