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COMPARATIVE ANALYSIS OF MILK YIELD AND REPRODUCTIVE TRAIT IN F1 AND *INTER SE MATED* CROSS DAIRY COWS

MSc THESIS

BY

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Bishoftu, Ethiopia

Comparative Analysis of Milk Yield and Reproductive Trait in F1 And *Inter Se Mated* Cross Dairy Cows

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

By

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DEDICATION

This research work is dedicated to my mother Lidiya Abdo and my two daughters Hafseva and Evana.

STATMENT OF THE AUHTOR

I confirm that this work is my original work, and that all sources of material used in it has been properly acknowledged. This thesis submitted as part of the requirements for an MSc degree at Addis Ababa University's College of Veterinary Medicine and Agriculture, and it has been put in the College Library to be made available to borrowers in accordance with the library's protocols. I affirm that this thesis is never submitted to any other institution for the intention of obtaining any an academic degree, diploma, or certificate. Brief extracts from this work are permitted without specific permission if the source is properly acknowledged. When the planned use of the material is in the interests of research, the head of the major department or the Dean of the College may grant permission for a lengthy quotation from or reproduction of this material in whole or in part. In all other cases, however, authorization from the author is required.

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BIOGRAPHICAL SKETCH

The author was born in Hawassa, capital city of Sidama Regional State, Ethiopia, on April 26, 1997. she attended her elementary education in Adventist 7th day Primary School and completed her high school studies at Tabor Senior Secondary and Preparatory School respectively. After passing Ethiopian Higher Education Entrance Examination successfully, she joined Jimma University in the 2016 academic year and graduated with a B.Sc. degree in Animal Sciences in July 2018. In September 20,2018 she was employed to the Ethiopian Institute of Agricultural Research and served as Junior Researcher for two years at Holetta Agricultural Research Center. Subsequently, in September 2021 she enrolled to Addis Ababa University, College of Veterinary Medicine and Agriculture, Department of Animal Production for the MSc study Program in Animal Production.

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ACRONYMS

AFC	Age at First Calving
AFS	Age at First Service
AI	Artificial Insemination
AMY	Annual Milk Yield
CADU	Chilalo agricultural development unit
CI	Calving Interval
CSA	Central Statistical Authority
CV	Coefficient of Variation
DMY	Daily Milk Yield
DO	Days Open
EARO	Ethiopian agricultural research organization
F1	First Generation Crossbred
F2	Second Generation Crossbred
F3	Third Generation Crossbred
GDP	Gross Domestic Product
GLM	Generalized Linear Model
HARC	Holetta Agricultural Research Center
HF	Holstein Friesian
ID	Individual Identity
LL	Lactation Length
LSM	Least Square Mean
NAIC	National Artificial Insemination Center
NGO	Non-Governmental Organization
NSPC	Number of Services per Conception
SAS	Statical analysis system
SD	Standard deviation
VWP	Voluntary waiting period
WWS	World wire sire

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COMPARATIVE ANALYSIS OF MILK YIELD AND REPRODUCTIVE TRAIT IN F1 AND *INTER SE MATED* CROSS DAIRY COWS

By

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ABSTRACT

This study was designed to evaluate the productive and reproductive performances of Boran x Friesian and Boran x Jersey cross bred dairy cattle with different exotic blood level at Holetta research center dairy farm. A total of, 10,360 cross breed dairy cattle performance records were castoff for the study. Non-genetic factors on the performance of crossbred dairy cattle were applied for estimation. The GLM analysis procedure of SAS 2004 software was employed to determine the fixed effects of year, season, parity, and genetic group. From these analyses, the performance of dairy cattle was influenced by non-genetic factors. Result of fixed effect analysis revealed that year and genetic group were caused significant (p<0.0001) variation in all productive and reproductive traits. Similarly, productive, and reproductive traits were also significantly (p<0.0001) influenced by parity except NSC trait. The traits, milk yield and calving interval were sensitive to seasonal variation. The overall least squares mean for daily milk yield (DMY), lactation length (LL), lactation milk yield, age at first calving, calving interval, and number of services per conception were ÷ 6.61 ± 0.04 kg, 329.2 ± 1.7 kg, 2152.4 ± 17.2 days, 38.35 ± 0.35 months, 488.7 ± 332 days, and 1.94 ± 0.06 respectively. Therefore, from the result of this study, it became viable to concluded that suitable choice on parental strains and crossing of them to provide calves of the following technology through enhancing the general control gadget withinside the farm needs to be carried out for in addition research.

Key words: Boran, Jersey, Holstein Friesian, productive performance, reproductive performance, non-genetic factor

1. INTRODUCTION

Ethiopia is among the rising countries in Africa with a vast cattle population. The weighed up entire livestock population in the country is around 60.39 million add up to male (45.32%) and female (54.68%). from whole cattle population in the country, the share of native breed is 98.24% and the left 1.54% and 0.22%, are hybrid and exotic breeds respectively. Dairy-cows are estimated to be near 6.66 million and milking-cows are about 12.39 million heads during the reference period (CSA, 2018/2019).

The desires for dairy products are expected to upsurge significantly as the human population increase at alarming rate in Ethiopia. In reply to the growing requirement for dairy products, the Ethiopian government has been enforced to amend productivity in terms of quality and quantity in the sector, through intensive husbandry with cross and exotic breeds (Million Tadesse and Tadelle Dessie, 2003; Firdessa, 2012). However, the sector is not advanced as it is anticipated when compared to east African countries like Keniya, Tanzania, and Uganda (Hunduma Dinka, 2013).

In Ethiopia breed advancement program begun during Italian occupation when pure temperate breeds imported to the country. (Aynalem Haile, 2006; Staal et al., 2008). Then cattle genetic advancement strategies have been undertaken by modifying the breed composition of local populations, either by introducing genes from an external source or through direct importation of exotic cattle breeds from the abroad (Habtamu Lemma et al. 2010). Still, the overall productivity and reproductive performance of these cattle are mostly relied on their adaptive efficiency in each environment (Nuraddis Ibrahim et al., 2011).

Holstein-Friesian and Jersey breeds are the most productive exotic dairy cattle breeds introduced mostly in central parts of Ethiopia, and are principal sources of milk and income, particularly in urban and peri urban areas. Despite this fact, reproductive and productive performances of these breeds are not well documented after the animals are familiarized and disseminated to different parts of the country (Hunduma Dinka, 2013). Moreover, in Ethiopia particularly in the lowland areas there is a need for critical inspection on reproductive and productive performance of these dairy cows (Sisay Eshetu, 2015).

Friesian and Jersey dairy breeds have been used by large scale private and state dairy farms in Ethiopia Even if there is worry about adaptation problems of exotic dairy cattle to the tropical environment (feed, disease, and weather condition). productive and reproductive traits are the most economically vital qualities, determine the fate of dairy viability (Fikere Lobago et al., 2007). Major elements for reproductive traits of breeding animals are Age at first service (AFS), age at first calving (AFC), calving interval (CI), days open till conception (DO) and the number of services per conception (NSPC), whereas daily milk yield (DMY), lactation length (LL) and lactation milk yield (LMY) are regular measure of productive performance of dairy cattle.

Holetta Agricultural Research Centers (HARC) is the core center that has been playing a great role in the improvement of different cross dairy cattle since 1960. This research center is mainly engaged in rearing Boran from indigenous cattle has mainly been crossed with Holstein-Friesian, Simmental, jersey and Horro with the intention of merging productivity and adaptability in the crossbreds This long-term crossbreeding effort led to in the development of various genetic groups (50% F1, F2, F3, 62.5%, 75% and 87.7%). Thus, estimation of phenotypic performance, for reproductive and milk production traits of Jersey and Holstein-Friesian dairy cows would help for genetic improvement of the herd, breed optimization and suggest future breeding processes as the whole.

Several studies Beyene (1992), Demek et al. (2003), Demek et al. (2004a, b), Haile et al. (2009a, b) and Kefena et al. (2011) and Kefale et al. (2017) have been done on dairy herd performance at HARC that weighed genetic and cross breeding effects on productive and reproductive traits. However, genetic, and non-genetic parameters of a population are not static due to environmental variability, ongoing selection, and use of different sires to create genetic variation in the farm, earlier valuation of non-genetic factors on the performance of crossbred could not mirror the current performance of herd in the farm.

1.2. Objectives of the study

1.2.1. General objective

To estimate phenotypic parameters for reproductive and milk production traits of Boran crosses with Jersey and Friesian at different exotic blood level.

1.2.2. Specific objectives

- ✓ To evaluate the reproductive and milk production performance of Boran x Jersey and Boran x Friesian dairy cows in the center.
- ✓ To assess the effects of non-genetic factors on the reproductive and milk production performance of Boran cross with Jersey and Friesian in the research center.

2. LITRATURE REVIEW

2.1 Historical overview of crossbreeding in Ethiopia

Ethiopia obtained the first high-grade cattle (Holstein Friesian and Brown Swiss) in the 1950's from united nation Relief and Rehabilitation Administration and since then started commercial milk production on government stations (Ahmed et al., 2004). Crossbreeding was not triggered till the year 1967/1968 when the Chilalo Agricultural Development Unit was founded at Asela station. This scheme, launched cooperatively by the Ethiopian and Governments of Swedish, made the first paces in familiarizing crossbreeding at smallholder farm level. Once recognizing the genetic advancement probabilities, similar dairy development programs were carried out in Ethiopia with aids from international organizations (MOARD, 2007). Thus, crossbreeding fired up by the Institute of Agricultural Research, over the setting up of an on-station Dairy Cattle Hybridization Platform, via Jersey, Simmental and Friesian sires crossed with the inhabitant Barka, Boran and Horro dams by the aim of testing the productivity of crossbred dairy cows with various degrees of exotic blood (EARO1, 2001). At some stage in the 1970's, governmental and non-governmental bodies have made numerous energies to advance the dairy sector by launching dairy cattle amendment farms and spread out crossbred F1 heifers to smallholder farmers (EARO1, 2001; Kelay, 2002).

The genetic enhancement trials for dairy production in Ethiopia mortified by several concerns. Climatic pressure in the form of erratic and insufficient rainfall; low feed yield and maximum price for concentrate and exposure to a wide variety of grave diseases adversely misfortune the productivity of genetically advanced dairy cattle especially the improved ones (ESAP, 2009).

2.2. Productive Performance

The productive performance of dairy cattle is particularly assessed by the total milk yield per lactation, average daily milk yield, lactation length, lactation tenacity, milk composition and lifetime production (VanRaden, 2003 and Zewudu et al., 2013). The reproductive performance and lactation performance of dairy cattle are directly allied with each other. Reproductive failure has a clear negative impact on milk production and farm income and verifies the future sustainability of a dairy farming task (Arbel et al., 2001).

Milk production is influenced by genetic and environmental components. Between the environmental aspects, the quantity and quality of offered feed resources are the chief ones. Productivity of a dairy enterprise rest on finding as high level of milk production as possible with accessible feeds, virtual to the maintenance cost of the animals. In Ethiopia, productive performance of crossbred dairy could not be pull off more than 7 liters of daily milk yield and 2500 liters of lactation milk yield with any one of the genetic groups in the last fifty years at on station circumstance even crosses were milked more than usual lactation period. However, current reports point out that more than 9 liters of daily milk yield were gained from crossbred dairy cows at on farm level (Kefyalew and Damtie, 2015; Mebrahtom and Hailemichael, 2016).

2.2.1. Daily milk yield (DMY)

Systematic decline in daily milk yield delivers a warning of instabilities in the milk production, which can be used as a tool for early warning, management decisions and forecasting production capacity of the herd. Estimating daily yields from one milking cow milked twice a day must also take in to reflection that morning milk yield are more persistent proportion of total daily yields than evening milk yields. The causes for lower milk production might be tied with weather condition, availability of pasture, rearing system, breed type, and stage of parity (Aynalem Haile et al., 2009a; Tadesse Birhanu, 2014; Kefale Getahun, 2018).

2.2.2. Lactation length (LL)

Lactation length is an important productive trait which stimuli the overall milk yield. In the majority of advanced dairy farm 305 day of lactation is accepted as standard for lactation length. (Msangi et al., 2005). On the other hand, such a standard lactation length might not work for smallholder dairy cows in which the lactation length is extended due to several factors. The profitability of short or prolonged lactation length rest on numerous aspects including the lactation length, lactation persistency.

According to Nibo Beneberu (2020), the mean lactation length for pure Jersey breed in Ethiopia was 344.89±3.81 days whereas, Kefale Getahun et al. (2020) reported 326.69 ± 2.03 for Boran x Friesian. Different value of lactation length trait has been reported by authors. This difference might be due to genetic makeup, production system, herd management with respect to feed, disease, and other environmental alterations (Kefale Getahun, 2018).

2.2.3. Lactation milk yield (LMY)

Boosting production of milk yield is the aim of dairy sector to achieve milk self-sufficiency. of the countries like Ethiopia and to increase the success of the dairy business. Thus, mainly genetic advancement plans of developing countries have intent on mending production performances of dairy cattle (Nibo Beneberu,2020). According to Kefale Getahun et al. (2020) and Nibo Beneberu (2020), the overall lactation milk yield and standard error of Boran x Friesian and pure Jersey in Ethiopia were 2204.05 ± 21.12 and 2166.10±26.71 kg, respectively.

Table. 1. Daily milk yield (DMY), Lactation length (LL) and Lactation milk yield (LMY) of dairy cows with different genetic groups.

Milk production traits				
genetic groups	DMY (Litters)	LL (Days)	LMY (Litters)	Source
Jersey	6.37±0.05	344.89±3.81	2166.10±26.71	Nibo Beneberu (2020)
50% HF	6.0±0.1	337 ± 3	2019 ± 26	Haile *et al.* (2009a)
HF x Boran	6.88±0.05	326.69±2.03	2204.05±21.12	Kefale Getahun (2018)
75%HF x Boran	6.92±0.25	358 ± 11	2336 ± 96	Million and Tadelle (2003a)
F1 Friesian	5.6±8	340.64 ±10	1908.06 ±11	Kefena *et al.* (2006a)
F2 Friesian	4.81±5	337 ± 5	1622 ± 5	Kefena *et al.* (2006a)
Jersey	6.25	336.17±2.3	2155±16.40	Direba Hunde *et al*. (2015)
75% Friesian	6.95±6	356.43 ± 6	2480.4 ± 7	Kefena *et al.* (2006a)
Jersey x Boran	5.21±0.05	-	1684.1±17.6	Gebregziabhere *et al*. (2014)
50%Jersey x Boran	6.1±0.31	337 ± 11	1956 ± 133	Demeke *et al.* (2004a)

HF= Holstein Friesian, HF x Boran= Holstein Friesian cross with

2.3. Reproductive traits

The basic objective of the dairy sector is to ride economically fit production, which is induced by reproductive effectiveness of the cows. According to (Cunningham and Syrstad, 1987; Kefena et al., 2006a; Hammoud et al., 2010) the importance of evaluating reproductive performance in cows. It is of fiscal value to the producer for a cow to produce a calf every year. The most familiar pointers of reproductive performance are age at first service, age at first calving, calving interval, days open, number of services per conception, breeding efficiency, calf crop and other fertility qualities.

2.3.1. Age at First Service (AFS)

Age at first service is a time which heifers attain body condition and sexual maturity for receiving service for the first time. AFS hints for the starting of heifers reproductive and productive, win over equally the milk yield and reproductive life of the cow and then influence her lifetime calf crop. A substantial lag in the attainment of sexual maturity may mean critical economic loss, due to an extra, non-lactating, unproductive period of the cow over several months (Belay *et al.,* 2012). Age at first service is impelled by genotype, nutrition, and other environmental factors. With good nourishing and supervision perhaps heifers that grow earlier and will cycle at an earlier time and exhibit behavioral estrus (Kollalpitiya *et al.,* 2012).

In Ethiopian at different production system jersey and Holstein Frisian with their crosses have showed diverse results in age at first services. The report of Kefale Getahun (2018) indicate 26.80 ± 0.34 on HF x Boran in another study Nibo Beneberu revealed the result of pure jersey Age at first service is 22.93±0.22 month. Age at first service is determined by several factors, which are internal factors like, genotype, growth rate, body size difference and body weight, as well as external factor, year or season of birth, rainfall, nutrition, thermal environment, photoperiod, rearing method, low level of management, poor feeding of calves and heifers at the earlier stages, grazing ability, utilization of poor pasture and diseases (Belay Zeleke, 2014; Nibo Beneberu,2020).

2.3.2. Age at first calving (AFC)

First calving smears, the starting of cow's reproductive cycle and milk production. Age at first calving is tightly associated to the rearing intensity, and has an influence on generation space and response to selection in a breeding program (Mukasa Mugerewa, 1989). under structured breeding system, heifers are commonly mated when they are mature enough to bear the stress of parturition and lactation. It is endorsed that heifers calve between 23 and 25 months of age, which is considered as peak that lead to escalation of the dairy business (Hammoud et al., 2010). Based on different scholars result age at first calving vary in different production system and their genotypic make up. Age at first calving for jersey breed was 22.93±0.22 as indicated by Nebo Beneberu (2020) in another report by Kefale Getahun (2018) was 37.42 ± 0.35 months for HF x Boran.

2.2.3. calving interval

Calving interval is the period between two consecutive calving. The calving interval was sectioned in two major periods, which were the calving to conception and the gestation times. The latter is fixed in length while the former varied depending on the type of breed and nutritional status of the cow. breed, calf size, calf sex, age of dam, month and year of calving are major factor which influence calving interval. In most dairy industries, the calving interval of 12-13 months was considered optimal.

The high calving interval may be related to weak management practices and other environmental stress that could disturb the animals return to estrus, heat detection, serving and conception (Desalegn Genzebu *et al.,* 2016). Hence, calving interval affects both the total milk production of the dairy herd and the number of calves born and it is considered as an important index of reproductive performance (Arbel *et al.,* 2001). Short calving interval of 12-13 month is the indication of good management and sound physiological status of the cow. Calving interval estimation for Friesian and Boran cross breed in different genetic group reported by Haile et al. (2009b) were 422 ± 10 days, 446 ± 12 days, 443 ± 11 days, and 443 ± 21 days for 50%, 62.5%, 75% and 87.5%.

Table 1. Age at first service (AFS), age at first calving (AFC), calving interval (CI) for different breeds of dairy cows in Ethiopia

	Reproductive traits			
genetic groups	AFS	AFC	CI	Source
Jersey	22.93±0.22	32.95±0.22	494.16±3.68	Nibo Beneberu (2020)
75% Jersey	-	42.52 ± 5	528.06 ± 5	Kefena *et al.* (2006a)
HF x Fogera	36.8 ± 0.8	-	-	Gebeyehu *et al.* (2005)
HF x Boran	26.80±0.34	37.42±0.35	476.35±3.91	Kefale Getahun *et al.* (2019)
75%HF x Boran	45.60 ± 2.6	340.64 ±10	2336 ± 96	Kefena *et al.* (2006a)
F1 Friesian	-	337 ± 5	477.77 ± 12	Kefena *et al.* (2006a)
F2 Friesian	42.81±5	336.17±2.3	512.6 ± 5	Direba Hunde *et al*. (2015)
Jersey	-	356.43 ± 6	497.08±3.69	Kefena *et al.* (2006a)
75% Friesian	6.95±6	-	1684.1±17.6	Gebregziabhere *et al.* (2014)
Jersey x Boran	5.21±0.05	337 ± 11	1956 ± 133	

2.2.5 Number of services per conception (NSPC)

The number of services per conception (NSC) is all number of services (natural or artificial), vital for successful conception. The number of inseminations expected to produce a live calf is one of the crucial indicators of reproductive efficiency, which heavily relies on the system used. It is greater under uncontrolled natural breeding than hand mating and artificial insemination. Values of NSC greater than 2 should be thought as poor (Mukasa Mugerewa, 1989). 1 to 1.7 is the recommended NSC for beneficial dairy cows (Evelyn, 2001). According to the report of (Yosef Tadesse, 2006; Habtamu Lemma et al., 2010; Direba Hunde et al., 2015), the NSPC of pure Jersey breeds are 3.07±0.08, 1.79±0.06 and 2.02±0.02, respectively. The average number of services per conception of Holstein Friesian cows in Ethiopia were reported to be 1.32±0.03 and 1.81 (Million Tadesse et al., 2010; Destaw and Kefyalew, 2018).

Table 2. Days open and number of services per conception for different breeds of dairy cows in Ethiopia.

Reproductive traits			
Genetic groups	DO	NSPC	Source
Jersey	221.09±3.73	1.99±0.03	Nibo *et al* (2020)
75% Jersey	-	1.77±0.03	Kefena *et al.* (2006a)
HF x Fogera	321 ± 27	-	Gebeyehu *et al.* (2005)
HF x Boran	197.10±3.88	1.10±3.88	Kefale Getahun (2018)
75%HF x Boran	256 ± 2.6	1.64±0.5	Gebregziabhere *et al.* (2013)
F1 Friesian	277±4.2	1.35 ± 0.3	Kefena *et al.* (2006a)
F2 Friesian	224.81±5	1.56 ± 0.44	Kefena *et al.* (2006a)
Jersey	-	2.02±0.02	Direba Hunde *et al.* (2015)

HF= Holstein Friesian, HF x Boran= Holstein Friesian cross with Boran Fogera= Holstein Friesian cross with Fogera

2.4. Non-genetic factors influencing productive and reproductive traits of dairy cattle

Non-genetic factors such as non-genetic factors include feeding (nutrition), housing, and management conditions; climate, including ambient temperatures; calving year, season, and age; number of lactations; body weight; estrus; number of pregnancies; disease; and milking frequency and duration influence the reproductive and productive performance of dairy cattle, which should be considered in the selection for increased production and reproductive efficiency of dairy cattle (Olawumi and Salako, 2010). Consciousness on these non-genetic factors and their influence on cattle reproductive and productive performance is important in the designing of management and selection decisions. In various studies, several factors have been included in analyses as main factors or their two and/or three-way interactions either as fixed effects or as continuous effects to account for environmental sources of variation in an animal's performance (Wasike, 2006). These factors, which can be considered as fixed effects and other stress-causing factors affect the performance of individual growth and reproductive performances in turn, affect the productivity of a given farm (Wasike, 2006 and Almaz Bekele, 2012). Different authors have reported that AFS and AFC are significantly affected by birth year (Yosef Tadesse, 2006; Aynalem Haile et al., 2009b; Habtamu Lemma et al., 2010; Berhanu and Ashim, 2014; Mengistu Worku et al., 2016). However, some authors have reported that these traits were not significantly affected by birth season (Aynalem Haile et al., 2009b; Almaz Bekele, 2012; Wassie Teketay et al., 2015; Kefale Getahun et al., 2019).

3. MATERIALS AND METHODS

3.1. Description of the Study Area

The study was conducted at Holetta Agricultural Research Center (HARC). HARC was established in 1966 under the Institute of Agricultural Research (IAR), now EIAR. The Center is in Welemera District, West Shewa Administrative Zone of Oromia Region, Ethiopia at Holetta town on the total area coverage of 396 ha and has two subs-centers. Holetta is in the central highland of Ethiopia at 29 km west of Addis Ababa at 9º 00' N latitude and 38º30' E longitude with an altitude of 2400 masl and under highland agro-ecology with an average annual rainfall of 1144 mm and an average temperature of 15 oC with minimum 6°C and maximum 22°C. The average monthly relative humidity is 60%. Soil type and coverage of the center is Nitosols and Vertisol which is characterized by an average organic matter content of 1.8%, total nitrogen 0.17%, pH 5.24 and available phosphorus 4.55 ppm. The season in the area is classified into 3 based on rainfall distribution. The main rainy season is between June and September while the short rainy season from March to May. The rest of the months are dry season which extend from October to February (Kefale Getahun, 2018; Fekadu wodajo, 2020) http://www.eiar.gov.et/holetta/index.php/about-holetta).map

3.2. Data Source and Data Collection

The data castoff for this study was sourced from records of Holetta Agricultural Research Center (HARC) dairy cattle herds farm with different crossbreed retained at the research starting from (1974 - 2020).

- ✓ Date of birth
- ✓ Age at first service (AFS).
- ✓ Number of Service Per Conception (NSC)
- ✓ Age at First calving (AFC)
- ✓ Days Open (DO)
- ✓ Daily milk yield, lactation length and total lactation milk yield, Parity, genetic group.

3.3. Animal Management

The cattle were herded in terms of their age, lactation stage, breed, pregnancy, and sex. Fixed routines of feeding and managing routines were applied for all animals. Natural grazing, hay and concentrate supplement constitute the main feed supply. Cattle were allowed to graze from early morning 8.00 AM to 4.00 PM in the afternoon for about 8 hours. The feed used as a basal diet (natural pasture hay) was harvested from on station grazing field. Natural pasture hay was supplied as required at night. Concentrate mixture of wheat middling (32%), wheat bran (32%), nough (Guizocia abyssinica) cake (34%) and salt (2%) was supplemented based on their body weight, productivity, and physiological categories. Milking cows, heifers and calves were supplemented a required standard of concentrate mixture in terms of their status at a rate of 4kg, 1-1.5 and 0.25-1kg per day, respectively. The cows had unlimited access to clean water all the time. In the center, calves are permitted to suckle their dam straightway after birth for about four days to receive colostrum. Weighting and ear tagging were also managed within 24 hours after birth. four days later calves were transferred in to calf rearing pen and keep on to fed a fixed amount of (260 liters of whole milk) milk for about three months within artificial rearing system (bucket feeding). Weaned calves were transferred to another pen and kept in door until six-months of age (HARC, 2019).

Until 2002, milking was held by hand, but since then milking machine was installed and cows have been milked with the milking machine twice daily (early morning and evening). Apart from for candidate bulls which were engaged for semen production, all redundant male calves and unproductive animals were culled from the farm. Supervision of the herd against any occurrence of diseases was a routine practice. Seasonal epidemics of major diseases of economic importance were detected and control measures were taken according to the disease control calendar set by the animal health research division of the HARC.

3.4. Breeding Program

Since its establishment, breeding activities of crossing purebred Boran with Friesian, Jersey and Simmental breeds created different genetic groups in the herd. Unfortunately, Simmental and Jersey crossbreeding activities were interrupted but their records were used in this study. The mating system was generated different genetic groups (50% F1, F2, F3 and few attempts were on high-grade of 62.5%, 75% and 87.5%). However, the 62.5% and 87.5% high-grade progeny developments were stopped and more emphasis are now being made at HARC for the development of 50% F1, F2, F3, 75% F1 and F2 crossbred dairy. Boran dams inseminated by pure Friesian semen for F1 50% and this generation crossed back with pure Friesian for 75% F1 formation. The later generations (F2 and F3) were produced by *inter se mating* 50% male with 50% female and 75% male with 75% female to produce synthetic breed at 50% HF and 50% Boran and 75% HF and 25% Boran blood level. The Boran cattle used as a base stock for crossbreeding were brought from Boran pastoralists in the southern Ethiopia and reared on station then mated randomly with NAIC Kality and WWS semen to produce required generations. The mating practice in the farm was undertaken throughout the year using artificial insemination, which brought from locally recruited crossbred bulls or pure Friesian semen from NAIC Kality, worldwide sires and sometimes natural service was used when animals became repeat breeder with AI. Bulls born in the farm were selected for breeding based on dam milk performance and physical conformation for semen collection in NAIC and used for on station breeding activities and care was taken during bull selection for NAIC to avoid genetic relationship.

Selection of bulls based on their breeding value is a recent work in the research station. Since 2010 cross breeding of Boran cows with exotic Frisian bulls using worldwide sire (WWS) imported semen by ALPPIS was initiated to further improvement, selection, and milk production as a recent activity at Holetta Agricultural Research Centre. In addition to herdsmen, teaser bull was reared with cows for heat detection every day. Cows detected in heat were mated using artificial insemination by qualified technicians. Cows not seen in heat after service or longer were diagnosed for pregnancy after 45 days of service. The on-station selection program was probably started since 2005 and was implemented by using 50% F1 Friesian X Boran and 75%

crossbred cows and bulls. Adequate information was generated through selection to maintain superior genotype for further production of crossbred dairy cows.

3.5. Data Management

Data Screening were carried out carefully to avoid manmade errors during data entry on individual animal card or in the computer writing. Therefore, data, which has not represented the herd, were crucial to clear before final analysis, which might have led to biased estimation.

During data clearing,

- ✓ lactation length below 100 days were removed from the data set which regarded as incomplete lactation for analysis of lactation milk yield, daily milk yield and lactation length.
- ✓ Age at first calving (AFC) below 20 month and above 90 months.
- ✓ Lactation records of ongoing also removed and above seven parities were pooled together in parity 8 because of few records.

Gestation period of the cow is close to 285 day and voluntary waiting period after calving is 45 days. Based on this assumption,

- ✓ cows that recorded below 330 days calving interval (CI) were removed from the analysis. A cow after calving needs some rest period for the uterus to involutes and normal cycle to take place. For this reason,
- ✓ a voluntary waiting period (VWP) ranging from 45 to 60 days were allowed before the cow was inseminated or bred (Gebregziabher et al., 2005). As a result, animals, which have shown estrus and bred earlier of 45 days were removed from the analysis.
- ✓ Repeat breeder cows more than10 times were very few compared from the rest of the population and were removed. The animals that have abnormal calving, i.e., abortion and stillbirths were not included in the analysis of breeding data.

3.6. Method of Data Analysis

Preliminary data analysis like screening of outliers and normality test were employed before conducting the main data analysis. Effects of non-genetic factors (genetic group, year, season, and parity) and least squares mean for reproductive traits (AFC, CI, NSC) and milk production traits (LMY, DMY and LL) were analyzed by the GLM procedures of SAS (2004) version 9.0 software to identify the important fixed effects which have a significant effect on the reproductive and milk production traits. Differences between least squares means of a trait for different genetic and non-genetic factors were tested using the Tukey-Kramer test based on the ANOVA result. Fixed effects which are significant ($P<0.05$) were fitted into the genetic model to estimate the genetic parameters.

Two steps of data analysis system were applied to conduct this research. SAS software package were used to determine the fixed effects of year, season, parity, of genetic groups. For comparison among genetic groups (model 1) the effects included in the model were genetic group, parity, season, and year (season and year of birth for age at first calving and season and year of calving for CI, LMY, DMY, LL and NSC). Genetic group included in the analysis were generally classified in to two based on the exotic blood levels (Boran x Holstein and Boran x Jersey). No selection and improvement have been undertaken on Boran breed since it has only been used as dam line for F1 generations. Therefore, performance evaluation of pure Boran breed was not the objective of this study and excluded from fixed effect analysis.

Developed genetic group for 44 years in the research center has not been presented continuously throughout the years. Various genetic groups were developed in different years based on the objective of the research direction. Due to the intermittent nature of crossbred development in the station, the years of calving ranged from 1981 to 2020 were grouped into 13 periods for convenient analysis of fixed effect. Each grouped year period consisting of 3 years.

For season of birth and calving, months of the years were grouped into 3 seasons based on rainfall distribution. Dry season from October to February, short rain season from March to May and main rain season from June to September. The presence of any significant differences within fixed effect was checked using least square mean separation of SAS procedure.

3.6.1. Least Square Analysis (Analysis of Fixed Effects)

In the preliminary analysis General Linear Model (GLM) procedures of the Statistical Analysis System (SAS 2004) version 9.0 were employed to determine and compare the fixed effects of different genetic groups, year, season, and parity.

Model 1: For productive and reproductive traits (LMY, DMY, LL, NSC, CI)

$Yijkln = \mu + Yi + Sj + Gk + Pl + eijkln$ Where;

Yijkln =n th record of, ith year, jth season, k th genetic group and l th parity

μ = overall mean

Yi = effect of ith Year of Calving

Sj = effect of jth Season of Calving (dry, October to February; short rain, March to May and long rain season, June to September).

Gk = effect of k th Genetic group (Boran x Holstein and Boran x Jersey)

Pl = effect of lth Parity of Dam (1, 2, 3, 4, 5, 6, 7,8)

eijkln = random error associated with each observation

Model 2: reproductive traits (AFC) were analyzed the main model without the effect of parity.

$Yijkn = \mu + Yi + Sj + Gk + eijkn$

Where, Yijkn = n th record of, ith year, jth season, k th genetic group

μ = overall mean

Yi = effect of ith year of birth

Sj = effect of jth season of birth

Gk = effect of k th genetic group

eijkn = random error associated with each observation

Table 3. Number of records used for non-genetic factor analysis.

	Number of observations in genetic group				
Trait to be studied	87.5%	75%	62.5%	56.25%	50%
DMY	6	556	116	32	2482
LL	6	556	116	32	258
LMY	6	556	116	32	2882
AFC	5	228	32	14	706
CI	11	153	88	20	1544
NSPC	9	120	65	33	1620
TOTAL	43	501	301	196	6620

DMY= daily milk yield, LL= lactation length, LMY= lactation milk yield, AFS= age at first service, AFC= age at first calving, CI= calving interval, DO= days open, NSPC= number of services per conception

4. RESULTS

4.1. Productive Performance and Their Fixed Effects

The criteria for the measurement of productive traits are total milk yield per lactation, lactation length and average daily milks which clearly indicate productivity of the animal over all performances of the herd.

4.1.1. Average daily milk (DMY)

Daily milk yield is a very important production efficiency trait, which is a union of milk yield and lactation length. The least-square means and standard errors of daily milk yield values are shown in Table 6. The overall least square mean and standard error of daily milk yield for 16 genotypes in the present study was 6.61±0.04kg. The result of the present study was slightly higher than the finding of Direba Hunde (2012) who reported a value of 6.25 kg for pure Jersey cows in line with the report of Kefale Getahun (2018) for Boran x Friesian 6.88 ± 0.05.

Daily milk yield obtained from 87.5% and 75% F1 Boran x Frisian had significantly ($P<0.0001$) higher compared to Boran x Jersey genetic groups. The increased Friesian blood level might significantly surge average daily milk. There is also significant variation($P<0.0001$) between parities (Appendix Table 1). This result was agreed with the finding of Gebregziabhere et al. (2014) for Jersey x Boran and HF x Boran higher daily milk yield was recorded at parity eight and the least is at parity one. An increase in average daily milk yield is observed after the fourth parity, although there is no clear significant difference, this result was agreed with Aynalem Haile et al. (2009a) for HF x Boran cross. in season of birth, Cows with lower parities had lower daily milk yield than those of higher parities. This is because cows become hormonally and physiologically stable as they mature enough.

According to trend analysis result (Figure 1) calving year have significantly affected DMY. The variation across the year this is due to different reason like weather, feed availability, management system at that particular year, disease occurrence and physiological status of the animals. The highest dmy was recorded at the year 2014-2016 while, the least was at the year of 1981-1983.

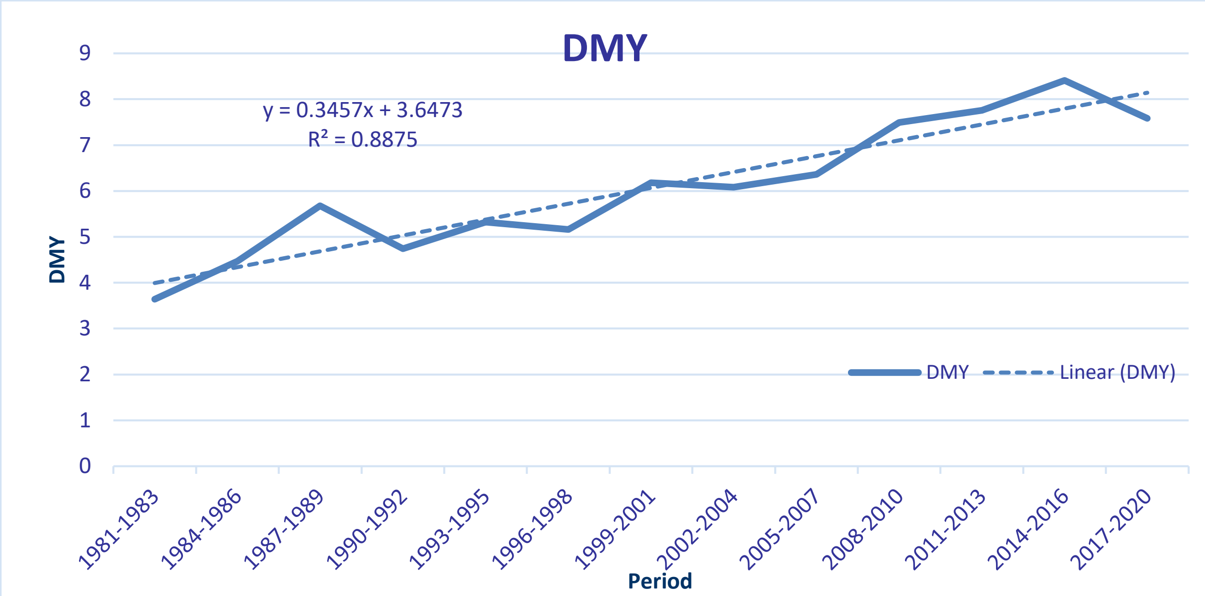

Figure 1 Trends of daily milk yield over the study year

4.1.2. Lactation Milk Yield

Lactation duration is an important production characteristic because it affects total milk production. The least-square means and standard errors of lactation length for fixed effects of genetic group, calving year, calving season, and parity are summarized in Table .6. The overall least square mean and standard error of LL for the present study was 329.2± 1.7days. This report agrees with Kefale Getahun (2018) who reported a value of 326.69 ± 2.03 for Boran x Friesian. Whereas, it is lower than the result of Nibo Beneberu (2020) for pure Jersey 344.89±3.81 days.

Analysis of variance (Appendix Table 2) showed that lactation length was significantly (P<0.001) affected by genetic group. Lactation length was higher for Boran x Jersey cows than Boran x Friesian. Lactation length was significantly (P<0.0001) affected by fixed effect of calving period (Appendix Table 2). This result is similar with Direba Hunde et al. (2015) for Jersey cows and Kefale Getahun (2018) for HF x Boran cross. Season of calving did not influence (p>0.05) lactation length (Appendix Table 2). This result was in line with the finding of (Direba Hunde et al., 2015; Kefale Getahun, 2018). Analysis of variance (Appendix Table 2) showed that lactation length was significantly

(P Analysis of variance (Appendix Table 2) showed that lactation length was significantly (P<0.0001) influenced by parity The longest lactation length was observed in parity one and the shortest was recorded on parity eight. Lactation length was significantly (P<0.0001) affected by fixed effect of calving period (Appendix Table 2). This result is parallel with Direba Hunde et al. (2015) for Jersey cows and Kefale Getahun (2018) for HF x Boran cross. Highest lactation length was recorded on cows born in during 2017-2020 and the lowest was observed during 2017-2020 with a difference of 284.7days.

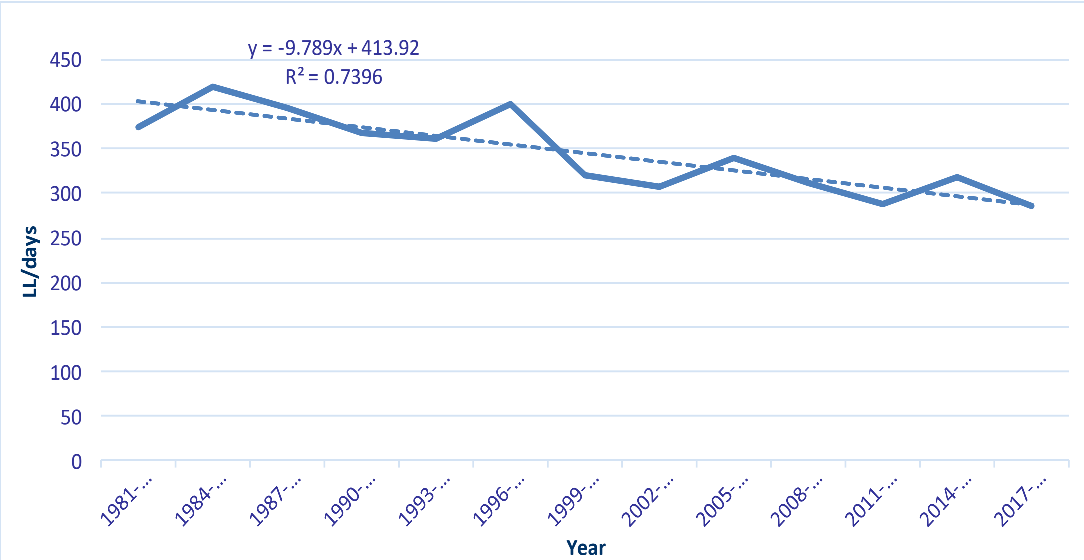

Figure 2 Trends of Lactation length over the study year.

4.1.3. Lactation Milk Yield

The overall lactation milk yield and standard error of LMY for the present study was 2152.4± 17.2kg. The result obtained in this study was comparable to the reports of Direba Hunde et al. (2015) who reported a value of 2155±16.4 kg. Calving year had significant effect on LMY (p<0.0001) (Appendix Table 3). This result agreed with Direba Hunde et al. (2015) for pure Jersey breed and Kefale Getahun (2018) for Holstein Friesian crosses with Boran. Calving season did not have significant (p>0.05) effect on LMY (Appendix Table 3). This result agreed with the finding of (Direba Hunde et al., 2015).

The analysis of variance (Appendix Table 3) revealed that lactation milk yield significantly ($p<0.0001$) differed among different parity. This significant effect of parity on LMY was similar with the reports of Direba Hunde et al. (2015) for pure Jersey breed, Kefale Getahun (2018) for Holstein Friesian crosses with Boran and Gebregziabhere et al. (2014) for HF x Boran and Jersey x Boran. Maximum lactation milk yield was observed in parity four (2259.3±48.9 kg) and minimum yield was recorded in parity one (2028.13±48.68 kg). There was no significant difference between parity four to eight on LMY.

Calving period had significant effect on LMY ($p<0.0001$) (Appendix Table 3). This result tie in with Direba Hunde et al. (2015) for pure Jersey breed and Kefale Getahun (2018) for Holstein Friesian crosses with Boran. The two calving periods (2014-2016) were the most favorable calving year for animals to perform better lactation milk yield (Figure 3). The highest average lactation milk yield was observed during 2014-2016 (2701.4±59.27 kg) while the lowest lactation milk yield was recorded in 1981-1983 (1236.00kg).

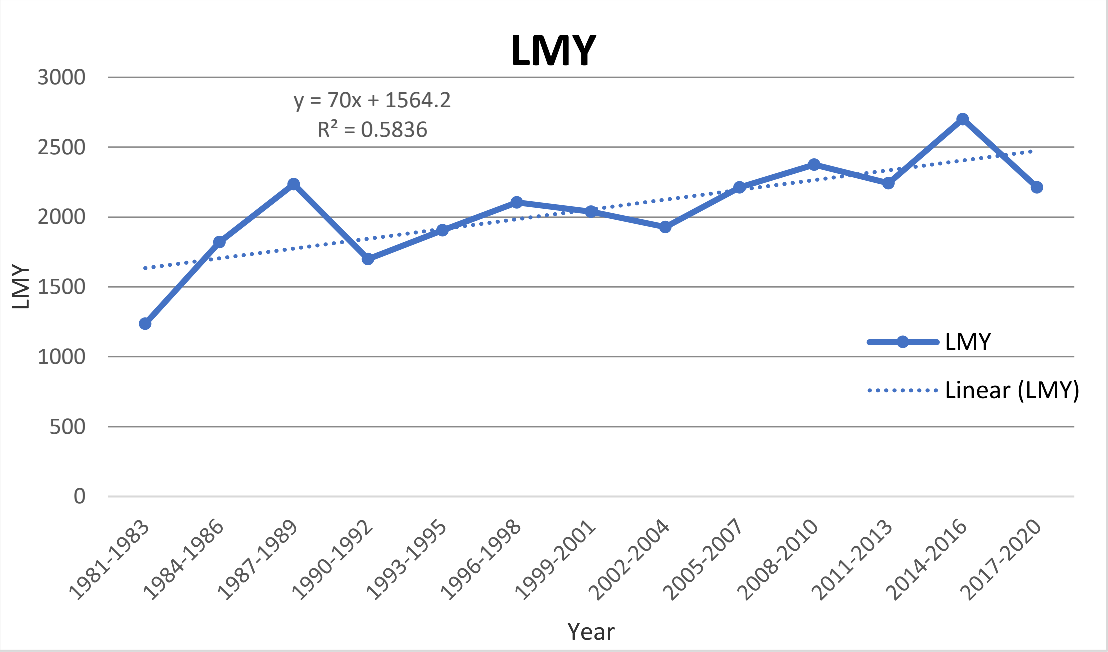

Figure 3 Trends of lactation milk yield over the year

Table 4. LSM and SD of DMY, LL and LMY of Boran crosses with Jersey and Holstein Friesian

Effect	N	DMY/litter	LL/day	LMY/litter
Overall mean	3,617	6.61±0.04	329.2±1.7	2152.4±17.2
Cv		29.00	26.72	40.0
genotype		****	****	****
12.5BO (87.5HF)	5	8.6±0.7	345.2±26.4	2979.4±360
12.5BO (87.5J)	1	4.98	426.00	2125.5
F1 25BO (75HF)	398	8.4±0.12	337.9±4.27	2895.8±58.5
F1 25BO (75J)	89	4.87±0.18	358.7±10.3	1709.2±72.4
F2 25BO (75HF)	59	8.4±0.12	314.3±11.3	2040.8±110.3
F2 25BO (75J)	10	4.87±0.18	364.7±21.9	1832.0±240.3
37.5BO (62.5HF)	76	5.12±0.66	363.09±15.04	2216.9±108.9
37.5BO (62.5J)	40	6.12±0.2	356.1±19.7	1817.7±114.9
43.75BO (56.25HF)	16	5.29± 0.35	298.4±22.5	1496.2±88.68
43.75BO (56.25J)	16	4.94±0.33	302.5±12.8	1494.9±118.2
50BO (50HF) F1	1641	7.16±0.05	316.5±2.1	2250.9±22.7
50BO (50J) F1	244	5.46±0.11	371.5±7.01	1989.0±54.05
50BO (50HF) F2	233	5.01±0.11	336.4±8.29	1659.5±48.9
50BO (50J) F2	175	4.45±0.10	346.9±8.11	1537.7±47.9
50BO (50HF) F3	140	5.14 ± 0.16	321.0±8.61	1632.2±62.4
50BO (50J) 3	49	4.52 ± 0.24	299.0±14.9	1313.0±75.6

Calving season		**	Ns	**
Dry season	1523	6.67±0.06	332.99±2.43	2197.9±24.9
short rain	867	6.35±0.08	324.1±3.33	2037.9±32.8
Main rain	793	6.77±0.08	327.6±3.49	2190.2±34.7
Calving year		****	***	****
1981-1983	51	3.64 ± 0.28	373.9±19.68	1236.0
1984-1986	79	4.47 ± 0.24	420.5±12.78	1821.5±
1987-1989	122	5.68 ± 0.15	396.4±10.12	2235.9±
1990-1992	249	4.74 ± 0.11	367.4±7.27	1700.8±
1993-1995	231	5.32 ± 0.11	360.9±8.33	1904.0±
1996-1998	188	5.25 ± 0.13	399.5±9.20	2104.1±
1999-2001	318	6.31 ± 0.11	321.1±4.24	2038.6±
2002-2004	290	6.15± 0.13	308.0±3.52	1928.0±
2005-2007	236	6.35± 0.14	339.6±5.37	2211.2±
2008-2010	285	7.49± 0.13	312.4±4.29	2374.2±
2011-2013	344	7.76± 0.12	287.7±3.74	2241.8±
2014-2016	383	8.41 ± 0.11	318.0±3.39	2701.4±
2017-2020	407	7.58 ± 0.09	284.7±3.92	2212.9
Parity		****		
1	872	6.04±0.07	334.39±3.1	2028.1±33.3
2	685	6.56±0.09	333.2±3.68	2186±37.7
3	518	6.95±0.10	322.9±4.11	2207.4±40.1
4	384	6.95±0.11	329.7±5.07	2259.3±48.9
5	286	6.85±0.15	328.8±5.88	2209±59.0
6	218	6.78±0.17	325.8±7.28	2131.9±66.5
7	138	7.13±0.24	319.4±9.39	2203.7±89.5
8	82	7.10±0.29	304.0±10.1	2115.1±99.9

*Cv=coefficient of variation, DMY=daily milk yield, HF=Holstein Friesian, LL=lactation length, LMY=lactation milk yield, J=jersey ****=p<0.0001, ***=p<0.001, **=p<0.01*

4.2. Reproductive Traits and their Fixed Effects

4.2.1. Age at First Calving (AFC)

The overall least square mean and standard error of AFC for the present study was 38.35±0.32 months. The result obtained in this study was higher than 32.95±0.22 months for Jersey breed reported by Nibo Beneberu (2020) and lower than the result of Gebeyehu Goshu et al. (2014) who reported a value of 40.83±0.46 months for HF. The factor which causes the variation might be production system, geographical area management, early heat detection and efficiency insemination, body conditions and physiological status of the cow. Calving season on AFC was showed non-significant effect in the present study the same result was revealed by different scholars (Aynalem Haile et al., 2009b; Kefale Getahun et al., 2019). The analysis of variance showed that there was a high significant ($P<0.0001$) effect of calving year This might be due to the selection of good animal, selection procedure, fortunate environmental condition, and virtuous management. Cows that born during 1984-1986 birth period require 22 additional months to attain AFS than those during 2011-2013 period. This variation could be due to management or health status of the cattle.

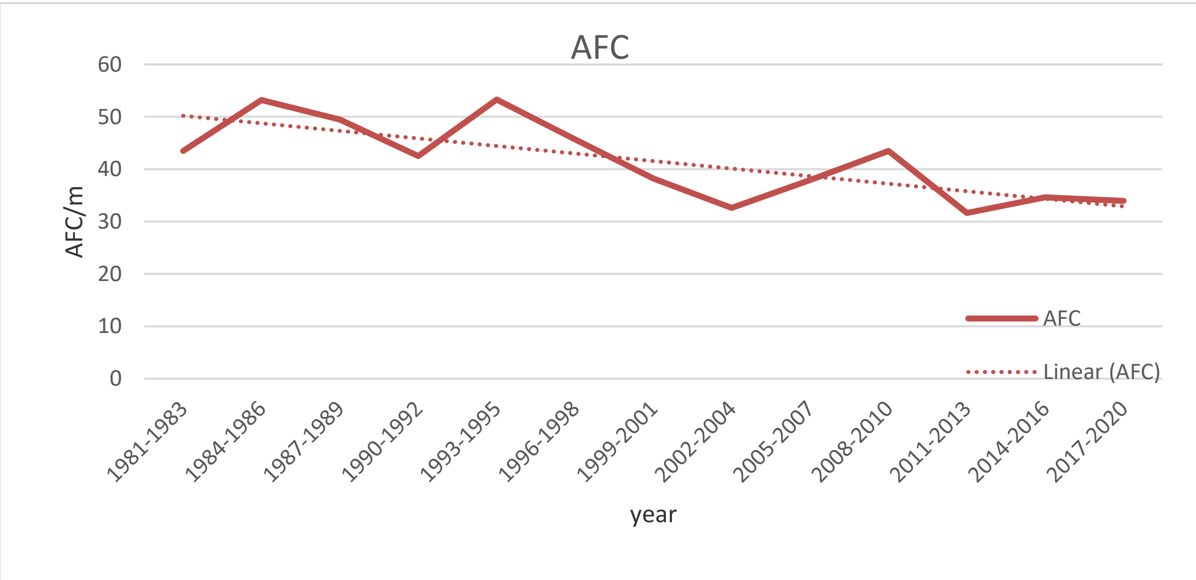

Figure 4 Trends of age at first calving over the study year

4.2.2. Calving Interval (CI)

The least square means and standard errors of CI for fixed effects of genetic group, calving period, calving season, and parity are summarized in Table 7. The overall least square mean and standard error of CI for Boran X Jersey and Friesian breed in this study was 488.7±4.02days. This result was analogous with the report of Nibo Beneberu. (2020) who reported a 494.16±3.68 days and contradict the result of Kefale Getahun et al. (2019) for 50% F2 Friesian cross with Boran (500.83±13.69 days). Calving season had a significant effect on CI ($p<0.05$). This significant effect of calving season on CI was in line with the report of Tadesse Birhanu (2014) for Holstein Friesian cross with Boran and Kefale Getahun et al. (2019). The significant ($p<0.0001$) effect of calving period observed in this study agreed with Direba Hunde et al. (2015) for Jersey breed. The lowest CI (409.8 ± 15.1 days) was observed on cows calved in during 1981-1983 followed by cows calved in during 2001-2003. The Longest CI (617. 1 ± 61.1 days) was observed for cows calved during 2017-2020 and this calving period was a characteristic of management problems like shortage of feed and health problems.

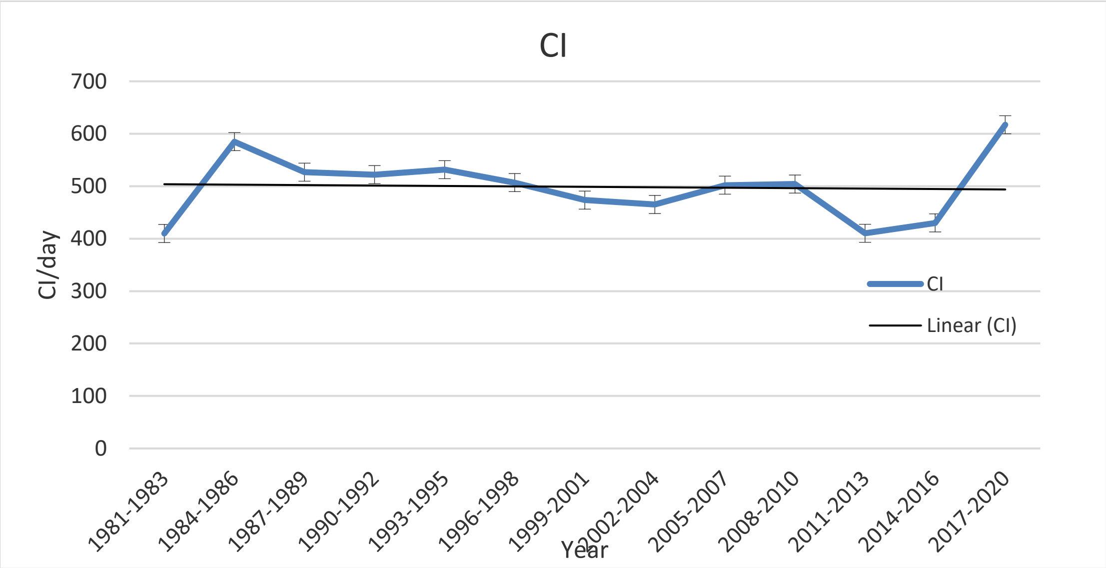

Figure 5 trend of Calving interval over the study year

Table 5.Least square means and standard errors of AFC and CI of Boran X Jersey and Friesian cattle

Effect	N	AFC	N	CI
Overall mean	985	38.35±0.32	1,806	488.7 ± 4.02
Cv		19.30		33.06
Genotype		****		****
12.5BO (87.5HF)	4	34.95±0.72	11	528.2 ± 21.4
12.5BO (87.5J)	1	58.800	9	408.0
F1 25BO (75HF)	161	36.8±0.65	63	526.2 ± 37.7
F1 25BO (75J)	47	46.51±2.92	68	496.6±17.3
F2 25BO (75HF)	17	36.5±1.01	16	446.6±37.7
F2 25BO (75J)	3	42.6±8.31	6	506.3±64.9
37.5BO (62.5HF)	21	53.92±1.79	57	548.8±22.7
37.5BO (62.5J)	11	48.22±3.04	31	443.7±18.2
43.75BO (56.25HF)	9	33.07± 1.56	8	485.2±49.9
43.75BO (56.25J)	5	28.1±0.83	12	435.5±29.5
50BO (50HF) F1	460	34.7±0.41	946	469.6±4.96
50BO (50J) F1	32	44.51±1.51	192	497.7±16.4
50BO (50HF) F2	88	45.2±0.91	157	539.4±14.0
50BO (50J) F2	40	47.9±1.80	135	517.3±18.3
50BO (50HF) F3	60	43.2 ± 1.29	87	497.2±15.7
50BO (50J) F3	26	37.9 ± 1.87	27	493.0±37.6

		Ns		Ns
Calving season				
Dry season	472	37.15±0.44	899	483.6±5.39
short rain	275	39.13±0.64	459	503.4±9.0
Main rain	238	39.8±0.66	448	483.8±7.77
Calving year		****		***
1981-1983	12	43.54 ± 2.8	16	409.8±15.1
1984-1986	43	53.25 ± 1.75	47	585.0±26.3
1987-1989	16	49.58 ± 2.07	81	526.7±23.7
1990-1992	34	42.57 ± 1.77	194	522.1±16.3
1993-1995	51	53.32 ± 1.1	188	531.5±14.1
1996-1998	29	45.76 ± 1.57	149	506.9±11.6
1999-2001	65	38.22 ± 1.28	197	473.5±12.2
2002-2004	114	32.63± 0.62	219	465.17±8.84
2005-2007	122	37.91± 0.71	137	502.0±11.7
2008-2010	98	43.47± 0.71	210	504.1±10.9
2011-2013	344	31.65± 1.00	258	410.2±4.97
2014-2016	383	34.64 ± 0.59	77	430.0±11.9
2017-2020	407	33.98 ± 0.45	33	617.1±61.1
Parity				****
2			447	533.4±8.16
3			384	487.6±8.31
4			306	480.1±9.91
5			247	481.4±12.9
6			202	456.3±10.2
7			139	453.6±12.2
8			81	442.7±99.9

*Cv=coefficient of variation, DMY=daily milk yield, HF=Holstein Friesian, LL=lactation length, LMY=lactation milk yield, J=jersey ****=p<0.0001, ***=p<0.001, **=p<0.01*

4.2.3. Number of services per conception (NSPC)

The number of insemination or repetition of mating for the successful conception is called number of Service per conception. The overall least square mean and standard error of NSpC for the present study was 1.94±0.06. The result of the present study was comparable with the report of Kefale Getahun et al. (2019) who found 1.97±0.09 Number of services per conception was significantly affected by fixed effect of service period ($p<0.0001$), parity ($p<0.0001$), service season group ($p<0.01$). However, animal group did not have significant effect ($p>0.05$) on NSPC (Appendix Table 6). The insignificant effect of animal group obtained in the present study did not agree with the finding of Direba Hunde et al. (2015) for Jersey breed who reported significant ($p<0.05$) effect of animal group on NSpC.The significant effect of service year on NSpC observed in the present study agreed with the finding of Direba Hunde (2012) for Jersey breed. The lowest NSPC was observed in animals served in during 1996-1998 (1.25±0.22) followed by those served in during 1984-1986 (1.46±0.27). However, the highest service per conception recorded was during 2005-2007 (2.65±0.08) (Figure 6).

The causes of difference in calving year on NSPC in this study might be due to variation of heat detection expertise of inseminator timing of insemination semen quality tacit ovulation of cows inconsistent feeding issue in terms of quality and quantity and environmental and weather change across the year variability. Analysis of variance has shown that genetic group and calving year had a significant effect on NSC but parity and calving season had not. The insignificant effect of parity and the significant effect genetic group obtained in the present study did not agree with the finding of Demeke et al. (2004b) who reported significant ($p<0.05$) effect on NSC trait. This might be depended on productive performance of cows in each management. High producing animals might be in stress and could not respond early for reproductive traits.

Cows inseminated during main rain season required more service than dry and light rain seasons. Although, many factors might have been contributed for seasonal variation on NSPC, shortage of feed is the main reason for repeat breeder of cows during main rain season because the pasture land was protected from grazing during this season.

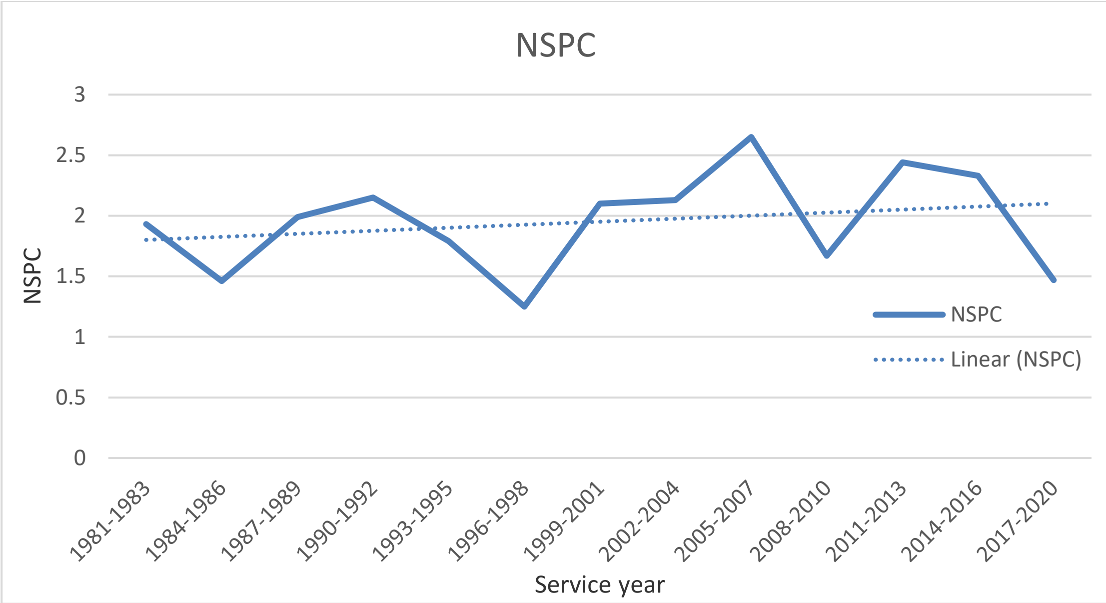

Figure 6 trends of number of services per conception over study year

Table 6. Least square means and standard errors of NSPC Boran x Jersey and Friesian cattle

Effect	N	NSPC
Overall mean	985	1.94±0.32
Cv		33
Genotype		Ns
12.5BO (87.5HF)	4	1.75±0.72
12.5BO (87.5J)	1	2.00
F1 25BO (75HF)	161	1.64±0.65
F1 25BO (75J)	47	1.63±2.92
F2 25BO (75HF)	17	1.27±1.01
F2 25BO (75J)	3	1.89±8.31
37.5BO (62.5HF)	21	1.73±1.79
37.5BO (62.5J)	11	1.74±3.04
43.75BO (56.25HF)	9	1.98± 1.56
43.75BO (56.25J)	5	1.28±0.83
50BO (50HF) F1	460	1.34±0.41
50BO (50J) F1	32	1.44±1.51
50BO (50HF) F2	88	1.64±0.91
50BO (50J) F2	40	1.47±1.80
50BO (50HF) F3	60	1.43 ± 1.29
50BO (50J) F3	26	1.37± 1.87

Calving season		**
Dry season	472	1.91±0.06
short rain	275	1.61±0.08
Main rain	238	1.77^{b}±0.08
Calving year		****
1981-1983	12	1.93 ± 2.8
1984-1986	43	1.46 ± 1.75
1987-1989	16	1.99 ± 2.07
1990-1992	34	2.15 ± 1.77
1993-1995	51	1.79 ± 1.1
1996-1998	29	1.25 ± 1.57
1999-2001	65	2.1 ± 1.28
2002-2004	114	2.13± 0.62
2005-2007	122	2.65± 0.71
2008-2010	98	1.67^{c}± 0.71
2011-2013	344	2.44± 1.00
2014-2016	383	2.33 ± 0.59
2017-2020	407	1.47 ± 0.45
Parity	**	
1	1.71±0.06	
2	2.16±0.06	
3	2.14±0.06	
4	1.78±0.23	
5	2.11±0.27	
6	1.97±0.34	
7	1.89±0.65	
8	1.78±0.56	

*Cv=coefficient of variation, DMY=daily milk yield, HF=Holstein Friesian, BO=Boran NSpC = number of services per conception J=jersey ****=p<0.0001, ***=p<0.001, **=p<0.01*

5. DISCUSSION

5.1. Daily Milk Yield (DMY)

Average daily milk is the major determinant factor for the sustainability of the farm as which it gives a clear indication on the performance of the herd. The present study revealed the least square mean and standard error for daily milk yield is 6.61±0.04kg. this result is lower than the report of Kefale Getahun (2018) for Boran X Friesian 6.88±0.05 while higher than the report of Direba Hunde (2012) who stated the value of 6.25 kg for pure jersey.

Daily milk yield obtained from 75% showed higher milk yield 8.4±0.7 in Boran x Friesian. The superiority of 75% genotype over the other exotic blood level was also reported by some other studies conducted in the Ethiopia (Million and Tadelle 2003; Haile et al., 2009). This might be the result of the increasing of exotic blood level effectively surg the potential milk production and also the indication of level of management (nutrition, medication and other rearing protocol) provided by the farm was good to boost the crossbred cows to gouge out their genetic potential also milking practice have effect on DMY when less frequent milking is prolonged, the decrease in milk production is sustained by chronological developmental adaptation, initially as a down regulation of cellular differentiation. milking time is another issue for DMY morning milking is consistent proportionally than evening milking.

The highest milk yield observed from Boran x jersey group is at 62.5% blood level group 6.12±0.2 which higher than the report of Tadesse Bekele et al (2007) 5.1 ± 0.35 kg for 62.5 % Boran x jersey group at the same farm. as blood level increased, reduction in their performance was observed, in Boran x jersey, slim difference in milk production was observed between 50 and 75% crosses Furthermore, mean milk production of 87.5% cross breed was lower than 75% cross breeds This could be justified as a reduction in epistatic effect A cross breed would retain less than 50% heterosis effect and have an additional loss due to recombination effects.
Milk production is one important aspect that has been shown to adapt to the seasons each year, also this study showed significant ($P< 0.05$) effect on daily milk yield.

Cows calved during dry and main rain season had produced better daily milk yield than short rain season. In the dry season, of course, the days continue to grow longer, while also warming up. The increase in daylight hours signals to a cow to produce more milk. This result is quarreling with Haile et al. (2009a) and Nibo Beneberu (2020) who found seasonal variation had not significant ($p>0.05$) effect on daily milk yield, while in agreement with Kefale Getahun (2010) stated season have significant ($P< 0.05$) effect on daily milk yield.

From the least square mean analysis of Table 6, year of calving significantly ($P<0.05$) affect daily milk year performance. this finding is in; line with Nibo Beneberu (2020) and Kefale Getahun (2018). The trend analysis for daily milk yield in this study was shown in Figure 1. The highest daily milk yield recorded 8.41±0.11 was during 2014-2016 and the lowest daily milk yield 3.64±0.28 was recorded during 1981-1983 calving periods. Low DMY for cows which calved in during 1981-1983. This variation might be caused due to change in climatic condition, feed availability, disease outbreak, composition of breed in the herd, other managemental issue.

There was significant ($P<0.0001$) difference among parity of cow on daily milk yield. Significantly ($P<0.05$) higher daily milk yield was observed in parity seven and lower was recorded at parity one. Even though, no clear significant difference was observed from forth to eighth parity, daily milk was increased as parity increase in this study. Haile et al. (2009a) also supported this result. The reasons for this increase could be the use of bulls with high genetic capacity, selection for milk yield and culling in the herd and especially improvement in management and feeding conditions The present result suggested that cow produce more milk as they become matured enough to bear the stress of gestation and lactation also, they attain physical and hormonal maturity which favor for increased milk production.

5.2. Lactation Length (LL)

The overall least square mean and standard error of lactation length for Boren x HF and J genetic groups in this study are shown in (Table 6). The average result of lactation length in this study was parallel with various studies Kahi et al. (1999), Haile et al.

(2009a), Kumar et al. (2014) and Dash et al. (2015) with the values of 326 ± 72(SD), 325 ± 3 days, 325.12 ± 61.28 days, and 326.57 ± 2.60 days, respectively. Marginally higher estimation from the present result was registered by Kefena et al. (2006b) and Kefena et al. (2011) with values of 360.76 ± 6.11 days and 343.8 ± 3.6 days. Nonetheless, lower estimation was reported by Djoko et al. (2003) 204 ± 27.8 days and Ashit et al. (2013) 234.0 ± 24.0 days). The alteration of the present result from authors reported elsewhere could be associated with genetic makeup, production system, feeding practice and other hysterical environment in which animals were maintained.

The analysis of variance (Table 6) indicated that lactation length was significantly ($p<0.05$) difference was observed between two cross breds as well on their filial generations. Boran x jersey showed higher lactation length than Boran x Holstein Friesian. Lactation length dropped in F2 and F3 crosses although the proportion of exotic genes are like that of F1 crosses. It might be due to halt down of flattering gene during gamete recombination. The short lactation length observed in second and third filial generation was influenced on their lactation milk yield. This result agrees with Kefale Getahun (2018) and Nibo Beneberu (2020). The longest lactation day in the present study was 426 day 87.5% of Boran x jersey and the shortest was 299±0.24 50% F3 Boran x jersey.

Season of calving did not influence ($p>0.05$) lactation length (Appendix Table 2). This result was in line with the finding of (Aynalem Haile et al., 2009a; Habtamu Lemma et al., 2009; Direba Hunde et al., 2015; Kefale Getahun, 2018). Trend analysis of lactation length based on calving year has shown that there is a decreasing pattern across 1984-86 to 2017-2010 which might be a management decision in which cows are milked 305 days to bring standard lactation length since 2003. Highest and lowest lactation length was recorded in 1984-86 and 2017-2020, respectively. However, no significant ($P>0.05$) values were observed between year 2002-2004, 2008-2010 and 2017-2020. This might be due to animals were favored by same management systems in this respective year.

On the other hand, least square mean has shown that parity significantly ($p<0.05$) affect lactation length. This report is in line with the report of Nibo Beneberu (2020) and Kefale Getahun (2018). The variation of values has been observed between parity on lactation length. The longest lactation length was observed in first parity and the lowest lactation length was recorded on eighth parity. Decreasing trend of lactation length was observed from parity one to eight (Lateef, 2007; Haile et al., 2009a and Deriba, 2012). This might be related with incomplete lactations because of early culling practice of the center and environmental factor like feeding as Successfully guiding cows through early lactation is key to their health and future performance.

5.3. Lactation Milk Yield (LMY)

Lactation milk yield is the amount of milk the cow produced at a single lactation period. Results of the least square mean and standard errors for LMY Table 6. The overall lactation milk yield and standard error of Boran x HF and jersey crosses in the present study was 2152.05 ± 17. 2 Kg. The overall mean result obtained in this study was slightly higher than the report of Gebregziabher et al. (2014) who found 2111.91 ± 16.88 for Boran x HF in central Ethiopia and Kumar et al. (2014) 2123.43 ± 65.67 kg for crossbred in Gondar, Ethiopia. Lower values were reported by various studies (Djoko et al., 2003; Ali et al. 2004; Kefena et al., 2006b; Haile et al., 2009a; Kefena et al., 2011 and Ashutosh et al., 2013) with 1703 ± 12.1 for crossbred in Ghana, 1336.88 ± 60.23 for Friesian x local in Bangladesh, 1919.6 ± 103.21 for Boran x HF crosses, 1798 ± 25 for Boran x HF crosses, 2088.7 ± 29.4 for Boran X HF crossbred in central highland of Ethiopia and 1506.75 ± 71.37 for HF x local in Bangladesh, respectively. However, relatively higher values of milk yield have been re-counted by Dash et al. (2015) 3976.77 ± 41.03 for HF x Keran Fries in India and Kahi et al. (1999) 3446 ± 1112 for Sahiwal, Brawn Swiss, and Ayrshire crosses. The difference of the present result from the authors reported elsewhere could be associated with genetic makeup, management, feeding practice and climate factor in which animals were managed and body condition of the cow.

Lactation milk yield was significantly ($p<0.0001$) affected by genetic group. In this study. Boran x Friesian showed better performance than Boran x jersey in lactation milk yield. 87.5% of Boran X Friesian produced 854 kg of milk than Boran x jersey crosses in a single lactation. The 75% F1 had produced higher milk yield per lactation compared with other blood level groups. while the 50% F1 has produced 25.5 % less milk than

75% F1 cows. This might be due to the increased Friesian gene level. The superiority of 75% genotype is also confirmed by (Million and Tadelle, 2003a and Haile et al., 2009a). whereas studies Demeke et al. (2004a), Kefena et al. (2006b) and Gebregziabhere et al. (2013) were not observed significant (p>0.05) difference between 50% F1 and 75% F1. Milk yield was decreased from 50% F1 to F3 and from 75% F1 to F2. This might be because of the significant recombination losses.

Trend analysis has shown that year of calving significantly (P<0.0001) affected lactation milk yield. The highest average lactation milk yield was observed during 2014-2016 (2701.78 kg) while the lowest lactation milk yield was recorded 1981-1993 (1236.0 kg). The three-year groups (1987-1989, 2008-2010 and 2014-2016) were the most favorable years for animals to perform better lactation yield (Figure 3). The alteration in milk yield from one-year group to other could be attributed to changes in herd size, composition of genetic group, stage of lactation, change of the climate, and inconsistent management practices introduced from year to year.

The least square analysis revealed that lactation milk yield was significantly (P<0.01) affected by season of calving. The present results suggested that milk yield was sensitive to seasonal variation. Least squares mean has shown that seasonal variation had significant difference on milk yield and higher average lactation milk yield was exhibited in dry season but the other two seasons were no significant differences. Seasonal variation on animal performance in the research station was expected to be primarily a manifestation of variation in feed quality and quantity. Cows calved during the long dry season might be enjoyed favorable environmental condition with better management in the farm resulting in significantly higher milk yield than other seasons. The analysis of variance revealed that lactation milk yield significantly (p<0.0001) differed among different parity (Appendix Table 3). Similar finding in Boran x HF crosses were reported by (Demeke et al., 2004a; Kefena et al., 2006b; Haile et al., 2009a; Gebregziabhere et al., 2013; Gebregziabher et al., 2014). Maximum lactation milk yield was observed in parity four and minimum yield was recorded in parity one. As shown from the list square means, lactation milk yield was increased from parity one to five and it gone with a constant rate from parity six to eight. There was no significant (P>0.05) difference from parity four to eight.

5.4 Age at First Calving (AFC)

Age at first calving (AFC), the period that a female calf needs to reach puberty and to reproduce for the first time, is an important factor in the cost of rearing replacements in dairy herds. Least square mean of genotype effect, calving season, and calving year on age at first calving are presented in Table 7. The overall mean of AFC in the present study was 38.35 ± 0.32 months in the range between 35.63 to 58.00 months. This result was similar with Berhanu and Chakravarty (2014) with 37.99 ± 0.30 months for Boran x HF and Jersey crosses. However, value of AFC obtained in the present study was lower than Obese et al. (2013) 41.2 ± 1.2 months HF x Sanga in Ghana, Belay (2014) 52.3 ± 1.77 for Fogera x HF and Wassie et al. (2015) 41.16 ± 0.56 for Arsi and Boran crossed with HF. This value was highest compared to other tropical countries. Hafez (1987) who found age at first calving extending from 24 to 36 months, Nibo Beneberu. (2020) 32.95±0.22 months for pure Jersey and Djoko et al. (2003) 877 ± 462.8 days for HF x Red Fulani in Cameron. These discrepancies between heifers might be due to variation in breed (genetic constitution), feeding management, heat recognition and on time servicing, culling practices, health status and climate difference. Genetic group and calving year had highly significant ($P<0.0001$) effect on AFC trait. List square analysis has shown that among genetic group, Boran X Jersey, and Boran X Friesian, in all exotic blood level Boran X Friesian performed better. Between 87.5% two genetic group Boran X Jersey delayed additional 24 months. 75% F1 had significantly lower AFC than 75% of jersey cross group. while 56.25% of jersey cross group registered the shortest AFC 28.1 month. There is no significant difference between 50% F2 and F3 and between 75%F1 and F2 in each specific groups.

Result comparisons among genetic group in this study was comparatively higher than Demeke et al. (2004b) who found the values of 36.0 ± 0.4, 39.6 ± 0.6 and 36.7 ± 0.7 months for 50% F1, F2 and 75% F1 crosses, respectively. Million et al. (2006) also reported lower value 35.90 ± 1.3 months, 41.91 ± 1.8 months, 45.60 ± 2.6 months for 50% F1, 50% F2, 50% F3 and higher value (40.77 ± 1.2 and 45.32 months) for 75% F1 and 75% F2 HF and Boran crosses and concluded that AFC was significantly increased by 4.86 months from 50% F1 to 75% and by 6 months from 50% F2 to 50% F1 crosses. The difference of the present result from others might be due to environmental variation, difference in number of observations being studied and management difference. Calving season had no significant ($p>0.05$) effect on age at first calving of crossbred heifers. Demeke et al. (2004b) and Million et al. (2006) also support the result of this study. However, Yosef (2006), Haile et al. (2009b), Million et al. (2010) Nibo Beneberu (2020) and Deriba (2012) found significant seasonal variation on AFC. These might be management, breed (genotype) and location (environmental) difference across the studied population and the sample size used for the study.

Highly Significant ($p<0.0001$) lower AFC value was recorded on animals born in 2011-2013 and whereas, animals born 1984-86 and 1993-95 have been scored higher value for this trait. It was expected that variation on management and climatic condition across the year and application of selection starts from 2005 in the farm might be change the results of AFC. Significant year variation on AFC were also reported by (Ababu et al., 2006; Yosef, 2006; Haile et al., 2009b; Million et al., 2010; Deriba, 2012; Belay, 2014; Tadesse, 2014). However, million et al. (2006) reported no significant ($p>0.05$) effect of year on AFC.

5.5. Calving interval (CI)

A calving interval of 365 days is considered as ideal for dairy cattle while a calving interval of less than 330 days tends to depress subsequent lactation performance (Bourchier, 1981). Least square mean and standard error of non-genetic factors on CI are summarized in Table 7. Genetic group, calving year group, season of calving and parity were affected CI trait in the present study. The present estimate was somewhat comparable with the reports of Nibo Beneberu. (2020) 494.16±3.68 days pure Jersey and Kefale Getahun. (2018) 476.35 ± 3.91 days for Boran crossed with HF. Lower result from the present study was reported by Suhban et al. (2000) 612 ± 4.6 for Pakistani crossbred and Ababu et al. (2006) 534.3 ± 17.64 days for Boran and Friesian crosses at Abernosa ranch. However, this result was higher than the finding of Belay (2014) 468.23 days for HF X Fogera crosses, Niraj et al. (2014) 453.6 ± 88.3 for HF crosses around Mekelle, Ethiopia and Tadesse (2014) 461.34 days Boran crossed with HF and Jersey. The variation of the present finding from others might be due to herd composition, management practice, climate, and geographical differences across the study area.

The longest calving interval of 528.2 ± 21.4days was obtained from 87.5% F1 Boran X Jersey and the shortest 408.0 days was from 87.5% F1 of Boran X Friesian crosses in the current study. Increasing level of calving interval was observed between 50% F1 and 75% F1. Mean calving interval significantly ($P<0.05$) increased by 48 days from 50% F1 to 50% F2 of Boran X Friesian and 57 days from 50% F1 to 75% F1 for the same genetic group. On the other hand, calving interval was 76 days significantly ($p<0.05$) reduced from 75%F2 to 50% F1 crosses for jersey crosses.

The difference of the present result might be due to heterosis and recombination effects in the F1, F2 generations. The longer or shorter CI might be related to LL traits. Cows showed longer CI when LL were longer in the present study. The genetic group comparison result of this study was slightly differed from the report of Demeke et al. (2004b) who found 417 ± 6, 435 ± 10 and 444 ± 13 days for 50% F1, F2 and 75% HF crosses. The significant ($p<0.0001$) effect of year observed in this study agreed with Million and Tadelle (2003a), Ababu et al. (2006), Million et al. (2006), Gebeyehu et al. (2007) and Haile et al. (2009b) but contradicted with the finding of Yosef (2006) and Deriba (2012) for pure Jersey and Holstein breed in the central highland of Ethiopia, and Belay (2014) for Fogera x HF crosses. This difference might be due to breed (genotype), management and geographical location effects.

Least square mean has shown that no marked difference has observed between long dry season and main rainy season. However, animals that calved during short rainy season have shown long CI (487.77 days). Animals allowed to graze grasses aftermath and green shoot during dry and main rainy seasons in the paddock and provision of concentrate supplementation might have a positive effect to cyclicity in the breeding cows. On the other hand, during the short rainy season animals might have not got optimum feed in the extensive grazing land. The significant ($p<0.05$) effect of season on CI was disagreed with the finding of Million and Tadelle (2003a), Haile et al. (2009b) and Belay (2014) who reported that no significance effect of season on CI trait.

The highest and lowest CI was recorded in parity two and parity three, respectively. The significance effect of parity on CI in this result is supported by Tadesse (2014) and Yohannes et al. (2016) but inconsistent with the finding of (Haile et al., 2009b and Belay, 2014).

The trend of CI was a gradual decreased to the 5th parity with the difference of 45 days between 2nd and 8th parity and constant from 5th to 8th parity. The decrease in CI as parity increase was due to the ability of the animal to recover the uterine environment within shorter periods as age increases and adaptation to parturition and lactation stress. However, statistically no significant difference was observed from 3rd to 8th parities.

5.6. Number of Service per Conception

The result of the present study was comparable with the statement of Kefale Getahun et al. (2019) who found 1.97±0.09 for 75% F1 crossbred and Direba Hunde et al. (2015) who conveyed a value of 2.02±0.02 for Jersey breed. This result was slightly higher than the report of Mengistu Worku et al. (2016) who reported a value of 1.30±0.06 for HF, Wassie Teketay et al. (2015) who reported a value of 1.32±0.06 for HF x Arsi and Habtamu Lemma et al. (2010) who reported a value of 1.79±0.06 for Jersey breed. However, it was lower than the result of Yosef Tadesse (2006) who reported a value of 3.07±0.08 for Jersey breed and Aynalem Haile et al. (2009b) who reported a value of 2.33±0.1 for Boran and its cross with Friesian. In fact, excellent herd management and performance of cows can be associated with lower services per conception.

Number of services per conception was significantly affected by fixed effect of service period ($p<0.0001$), parity ($p<0.0001$), service season group ($p<0.01$). However, genetic group did not have significant effect ($p>0.05$) on NSPC (Appendix Table 6). The insignificant effect of animal group obtained in the present study did not agree with the finding of Direba Hunde et al. (2015) for Jersey breed who reported significant ($p<0.05$) effect of animal group on NSPC. The least square mean of NSPC showed for Boran x Jersey cows require more service per conceptions (2.08±0.07) than Boran x Friesian cows (1.91±0.03) which could be associated with more reproductive efficiency Boran x Friesian cows. 75% F2 genetic group had required lower (1.33) number of services per conception while 75% F1 had required higher (1.97) NSC. This might be depended on productive performance of cows in each management. High producing animals might be in stress and could not respond early for reproductive traits, Favorable negative recombination effect on the F2 and F3 generations for NSC trait might be also an effect on this variation. Demeke et al. (2004b) reported 0.07 ± 0.11 NSC was reduced when Boran was crossed with HF. No significance ($p>0.05$) difference has been observed between 50% F1, F2 and F3 and between 50% F2, F3 and 75% F1 genetic groups. The 50% F1 and 75% F2 genotypes have shown a better performance for this trait in both genetic groups.

The significant effect of service period on NSPC observed in the present study agreed with the finding of Direba Hunde (2012) for Jersey breed. The lowest NSPC was observed in animals served in during 1984-1986 (1.46±0.08) followed by those served in during 2017-2020 (1.47±0.12). However, the highest service per conception recorded was during 2011-2013 (2.44±0.08) (Figure 6). The significant difference in period of service on NSPC in the present study might be due to variation of heat detection, skill of inseminator, time of insemination, semen quality, silent ovulation of cows, inconsistent management (feeding) and environmental variability.

Cows inseminated during main rain season required more service than dry and light rain seasons. Although, many factors might have been contributed for seasonal variation on NSPC, shortage of feed is the main reason for repeat breeder of cows during main rain season because the pasture land was protected from grazing during this season. The significant effect of service season on NSPC was agreed with Yifat Deberga et al. (2009) for HF x Zebu and Jersey x Zebu and Wassie Teketay et al. (2015) for HF x Boran and HF x Arsi. On the contrary (Yosef Tadesse, 2006; Aynalem Haile et al., 2009b; Mengistu Worku et al., 2016; Kefale Getahun et al., 2019), found that service season did not have significant effect on NSPC. The significant effect of parity on NSPC observed in the present study agreed with the finding of Direba Hunde (2012) for Jersey breed. On the contrary (Habtamu Lemma et al., 2010; Mengistu Worku et al., 2016; Kefale Getahun et al., 2019), found that parity did not significant effect on NSPC. The lowest NSPC was observed in the first parity (1.71±0.06) and the highest NSPC was recorded on 2nd parity (2.16±0.06). However, statistically there were no significant difference between 3rd, 5th, and 8th parity.

6. CONCLUSION AND RECOMMENDATION

6.1. Conclusion

The present study was specifically designed to evaluate the performance of Boren x Friesian and Boren x Jersey crossbred with different genetic groups. The long-term data of 10,360 crossbred maintained at Holetta Agricultural Research during the period of 1983 through 2020 were utilized for this study. With this regard, the objective was to evaluate the extent non-genetic effect on productive and reproductive (LMY, DMY, LL, AFC, CI and NSC) performance.

From this study, the performance of dairy cattle was influenced by non-genetic factors. The productive and reproductive traits measured shown significant variation among genetic groups, birth year groups, calving year groups, birth seasons, calving seasons, and parity and which indicating that a remarkable improvement can be achieved through better management decision.

Comparisons between two crosses did reveal a definite superiority of Boran x Friesian over Boran x jersey. Milk production in the first-generation crosses increased more compared to second generations. There were marked decline in performance among 50% F1, F2 and F3, which indicated the importance of retaining heterosis. Back crossing the F1 to the European breeds have brought an increase milk yield in this study. The 75% F1 had produced superior milk per lactation and the breed of choice for milk production trait compared with other genetic groups and has produced 25.5 % more milk than 50% F1 in this study. This high level of production could, however, not be maintained in the second or latter generation crosses because heterosis reduction. The higher milk yield of first generation (50% F1 and 75% F1) crosses from its contemporary group was also associated with longer lactation length. The 50% F1 genetic group was also characterized by better reproductive performance (calved early, shorter calving interval). Unlike their superiority of production traits, the 75% F1 cross was poor in reproductive performance. Furthermore, it was expected that the 50% second and third generation were belonged with their poor reproductive performances. In association with shorter lactation length, the 75% F2 generation was good in calving interval traits. However, no any one of the genetic groups was exerted a significant effect on NSC trait. At HARC, Boran and different exotic genetic groups have been evaluated for reproductive (AFC, CI, and NSC, etc.) and productive (milk yield and LL) performances (Beyene 1992; Demeke et al., 2004 a, b; Haile et al., 2009a, b and Kefena et al., 2011) and Kefale Getahun (2018) most of the studies reported the superiority of the crossbreds (F1) over the indigenous breeds and later crossbred generation in some of economically important traits. Due to inter annual random change of environment, management, herd structure and stage of lactation, productive and reproductive traits were significantly affected by year, season, and parity. Trend analysis has shown that there was an overall improvement of the productive and reproductive performance of herd in the station since 2002 and then. The highest average lactation milk yield was observed during 2014-2016 (2701.78 kg) and constant up until 2017. However, animals were showed poor overall performance in the year 1981-83 and 2002-2004.

Milk yield and calving interval are sensitive to seasonal variation. In the present study cows calved during dry season was gave more milk (2162.46 ± 54.70 liter), shorter calving interval (455.78 days). However, lactation length, age at first calving and service per conception were not affected by season.

Milk yield increased significantly from first parity and reached maximum at five and it gone with a constant rate from parity six to eight. Lactation length and calving interval decreased while parity increased. The longer lactation length was observed in parity one and two whereas shortest lactation Length was recorded in parity eight. From 2nd to 5th parity calving interval was significantly decreased and then increased with insignificant values but the lower values for both traits were observed at parity eight in both genetic groups.

6.2. Recommendation

The following recommendations were drawn from this study:

- ✓ Enhancement on the level of feeding, breeding and health management should be done for improvement of reproductive and milk production traits.

- ✓ Estimation of phenotypic performance, values figured out in this study can be used as a base for selection and continuous estimation of these parameters should be implemented in the center.

- ✓ The selection method of the farm must be based on both phenotypic and genetic evaluation results rather than only phenotypic performances.

- ✓ A standard record keeping practice on reproductive, milk production and growth traits should be established.

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APPENDIX

Appendix 1: Table 1. Analysis of variance for daily milk yield

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Genetic group	15	1646.923565	109.794904	29.85	<.0001
Calving year	12	2098.566660	174.880555	47.55	<.0001
Calving season	2	36.464674	18.232337	4.96	0.0071
Parity	7	929.518753	132.788393	36.11	<.0001
Error	3146	11570.14337	3.67773		

Appendix 2: Table 2. Analysis of variance for lactation length

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Genetic group	15	685563.528	45704.235	5.91	<.0001
Calving year	12	4162081.911	346840.159	44.82	<.0001
Calving season	2	9013.980	4506.990	0.58	0.5586
Parity	7	209336.904	29905.272	3.86	0.0003
Error	3146	24347690.03	7739.25		

Appendix 3: Table 3. Analysis of variance for daily milk yield

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Genetic group	15	368286060.9	24552404.1	33.06	<.0001
Calving year	12	171373257.6	14281104.8	19.23	<.0001
Calving season	2	5958132.7	2979066.3	4.01	0.0182
Parity	7	49762314.6	7108902.1	9.57	<.0001
Error	3146	2336627642	742730		

Appendix 4: Table 4. Analysis of variance for age at first calving

Source	DF	Type III SS	Mean Square	F Value	Pr > F
genetic group	15	8840.07427	589.33828	10.75	<.0001
Calving year	12	22986.51542	1915.54295	34.95	<.0001
Calving season	2	255.38337	127.69169	2.33	0.0979
Error	955	52341.2674	54.8076		

Appendix 5: Table 5. Analysis of variance for Calving interval

Source	DF	Type III SS	Mean Square	F Value	Pr > F
genetic group	15	684805.660	24552404.1	1.87	0.0250
Calving year	12	3714836.631	14281104.8	11.85	<.0001
Calving season	2	103204.159	2979066.3	1.98	0.1390
Parity	6	1777490.283	7108902.1	11.34	<.0001
Error	1771	46254356.62	26117.65		

Appendix 6: Table 6. Analysis of variance for Number of services per conception

Source	DF	Type III SS	Mean Square	F Value	Pr > F
genetic group	15	36.33329711	9.08332428	5.76	<.0001
Service year	12	2.59824930	1.29912465	0.82	0.4389
Calving season	2	37.99837155	5.42833879	3.44	0.0011
Parity	6	14.62772918	2.08967560	1.32	0.2341
Error	1771	3958.719118	1.577179		

Appendix 7: Ethical Clearance

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Animal Research Ethical Review Committee

Ethical clearance certificate

Certificate Ref. No: VM/ERC/32/03/15/2023

Name and affiliation of applicant: **Danayit Alem (BSc, MSc student)**
Department of Animal Production Studies, College of Veterinary Medicine and Agriculture, Addis Ababa University

Title of the project: *Comparative analysis of milk yield and reproductive traits in F1 and inter se mated cross dairy cows*

Date of application:	**January, 2023**
Nature of the project:	**retrospective farm record analysis**
Target animal species:	**Cattle**
Number of animals involved:	**No animal use**
Study area:	**Holeta research Center, Ethiopia**

Minutes No. and date of review: **VM/ERC/04/15/022, 02/02/2023**

The Animal Research Ethical Review Committee of the College of Veterinary Medicine and Agriculture of Addis Ababa University has reviewed the above research project and unanimously approved the application of Danayit Alem.

The Federal Democratic Republic of Ethiopia * Addis Ababa University College of Veterinary Medicine and Agriculture *

Professor Getachew Terefe (DVM, PhD)
Chairman

Signature

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