Reproductive performance of crossbred dairy cattle under semi-intensive management system in Arsi highland, Ethiopia

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Abstract

Dairy cattle genetic improvement mainly focuses on improving reproductive performances. The improvement of dairy cattle reproductive performance increasesthe number of calves per year, decreases calving interval, and reduces the number of services per conception. The low reproductive performance of local cattle rapidly improved through crossbreeding with exotic dairy breed sires. Therefore, this research was designed to estimate the reproductive performance of crossbred dairy cattle and determine factors that influence reproductive trait performance. The reproductive performance of crossbred dairy cattle has been analyzed using farm recorded data. The AFC of crossbred dairy cows was 57.1 months, and the performance significantly (P<0.01) varies among cows' birth year. CI and DO of crossbred dairy cows were 422.2 and 131.4 days respectively, and the traits show a significantdifference (P<0.001) among birth year and parity. Calving year and calving seasons had a significant effect (P<0.05) on the two traits. Birth season and genotype did not show significant effect on the cow'sage at first calving, days open, and calving interval. The mean NSPC was found 1.5 and all the variables did not show a significant difference in the trait. The least-square mean of the traits shows a significant improvement trend across the different birth years. The higher performance record and the irregularity of the performance across birth year, and the insignificant effect of the different genotypes might be due to management and absence of selective breeding.

Keyword: *Age at First Calving; Calving Interval; Crossbred; Days open; Reproductive Performance*

Introduction

Tropical dairy production systems are characterized majorly by smallholder farming systems and low animal performance. Poor genetic potential of indigenous cattle for milk production, low level of animal husbandry practices, inadequate feed supply, and disease prevalence are among other factors that limit animal performances(Alemneh, 2019). In this regard, increasing the genetic potential through selection is too slow and requires many generations. Even though, the selection is one of the genetic improvement tools, it must be supported by efficient and persistent recording systems and progeny testing that are not well established in developing countries. The small number of animals per household and desire for an immediate response from the recording, lack of know-how influences implementation of the recording system and genetic improvement(Biscarini et al.,2015).

Traditional and subsistent milk production are characteristics of Ethiopian dairy production systems. Before the introduction of exotic dairy breeds, milk production was purely from the local cattle. The first modern dairy production system started after the introduction of exotic dairy breeds during the Italian occupation. In the 1947, the country received 300 Friesian and Brown Swiss dairy cattle donated by the United Nations Relief and Rehabilitation Administration(Staal et al., 2008; Yigezu, 2000) that contributed much to the establishment of private dairy farms in the country (Ahmed et al.,2004). Later, in the 1950s large scale, cattle crossbreeding program was started by the Institute of Agricultural Research and Chilalo Agricultural Development Unit which was later named Arsi Rural Development Unit using Holstein-Friesian, Jersey, and Simmental exotic sires and the local *Horro, Boran, Arsi, Fogera, and Barka* dams (Ahmed et al., 2004; Kiwuwa et al., 1983). The crossbreeding program aimed to produce F_1 heifers to distribute for farmers and to test the productivity of crossbred dairy cows of different breed combinations.

Dairy cattle genetic improvement can be achieved by improving the reproductive trait performance through crossbreeding(Belay, 2016; Sørensen, 2000). Best reproductive success in a cattle herd increases amount of calf per year, decreases calving interval and reduces the number of services per conception (Diskin & Kenny, 2014).Generally, crossbreeding activity in Ethiopia has substantially decreased age at first calving, reduced calving interval, days open till conception, and reduced the number of services per conception as compared to the local cattle breeds (Demeke et al., 2004; Negussie et al.,1998). However, reports have revealed the absence of a strategic crossbreeding plan and selective breeding result decreasing genetic gain in crossbred dairy cattle (Effa et al., 2011)

Indigenous cattle breeds and their cross breeds contribute much to design appropriate breeding strategy that requires accurate performance evaluation. One of the measures of productivity of a cow is its reproductive success. For example age at first calving performance and calving interval of crossbred dairy cattle managed under semi-intensive management has been reported 40.2 months and 411 days (Demeke et al., 2004), and42.5 months and 462 days (Effa et al., 2011).While, age at first calving and calving interval of crossbred dairy cows kept under intensive feeding and management system reported 41.8 months and 405.5 days, respectively (Mengistu et al.,2016). Reproductive performance of crossbred dairy cattle under crop-livestock mixed farming, market-oriented specialized dairy farm, urban dairy farm, and research station dairy farm reported 41 months age at calving, 552 days calving interval and 1.7 number of service per conception(Shiferaw et al., 2003). Comprehensive information on the reproductive performance of crossbred dairy cattle and influencing factors of the traitsunder a semi-intensive management system is limited. Thus, the objective of this study was to estimate the reproductive performance of crossbred dairy cows and to determine factors that influence the traits under a semi-intensive management system.

Materials and Methods

Description of the study area

The data used in this study was a result of crossbreeding program of Arsi University dairy farm, previously called Asella Livestock Farm, in Arsi zone Ethiopia from 1998 to 2013. The farm was established in 1967 by the former Arsi Rural Development Unit (ARDU) for the multiplication and distribution of crossbred heifers for farmers. The area is located about 175 km southeast of Addis Ababa at a longitude of about 39°.6'.46.1" East, a latitude of 7°.55'.58.3"North and altitude of 2366m.

The area is characterized by mild subtropical weather with maximum and minimum temperatures ranging from 18 to 22°C and 5 to 10 °C, respectively. It experiences bimodal rainfall with annual average precipitation of 1270 mm. A short rainy season occurs from March to May followed by a long rainy season lasting from June to September. The long dry season lasts from October to February. The vegetation cover consists mainly of annual legumes and perennial grass species. The grass species in the natural pasture include grasses such as *Chloris gayana, Setaria sphacelata,Panicum coloratum,*and many useful legumes such as *Trifolium semipilosum, Glycinewightii,*and *Trifolium burchallianum* (Kiwuwa et al., 1983).

Breeding Program

Crossbreeding indigenous cows (Arsi, Boran, Fogra, and Barka) with introduced Friesian and Jersey sires was started in 1967/68 to combine high adaptability of indigenous cattle (resulting from more or less natural selection) with a high productive potential of European dairy breeds. The main objectives of crossbreeding at this dairy farm were to produce F1 heifers of 50% *Bos taurus* and 50% *Bosindicus* and distribute them to model farmers and to test the performances of different breed genotypes and levels of upgrading (Kiwuwa et al., 1983). Since then, the upgrading and backcrossing breeding has continued for nearly 50 years. As a result, the genotypes available on the farm are a combination of different genetic of Holstein, Jersey, Arsi, Boran, Fogera, and Barca (now called Begait) breeds.

Herd Management

Newly purchased local heifers were kept in quarantine for at least **3** weeks checked for disease and put on liberal feeding regimes based on pasture, hay, and concentrates. Normally, however, the breeding herds were grazed on pasture and were fed on hay and concentrate supplements during the dry season. Shortly after birth, new-born calves were taken away from their dams and isolated in a calf pen. They were provided milk on bucket till weaning, to the age of 90 to 120 days. Colostrum, whole milk, and milk substitutes were fed to calves twice daily at a rate of 1.0 kg to 2.5 kg of milk equivalent per day. Animals on the farm were routinely vaccinated against anthrax, blackleg, pasteurellosis, and lumpy skin disease. Regular dosing against internal and external parasites is applied every three months. Cows were regularly cheeked formastitis infection before milkingand cows infected with mastitis were treated separately.

Traits studied

Age at first calving, calving interval, days open till conception, and the number of services per conception reproductive traits of crossbred dairy cattle was studied. Age at first calving (AFC) is the age (in months) at which a heifer gives birth to its first calf. The analysis for this trait was conducted for heifers, which were born on the farm. Calving interval (CI) Is a trait which indicates the length of period (in days) between two consecutive calving of a cow. Days open to conception (DO); is a trait that measures the period in days between parturition and subsequent conception. The number of services per conception (NSPC) is the number of services required for a successful conception. It is the number of inseminations for a successful pregnancy. Each trait was calculated from individual records kept on date of birth, mating, gestation, and parturition.

Data recording, management, and analysis

All animals on the farm were assigned individual ear tag numbers. At each live delivery, the date, dam and sire id, breed, sex, weight, and individual identity of the calf were recorded. The date of insemination, number of services (AI),and date of calving were recorded and the NSPC, AFC, CI, and DO traits were calculated from the records. The data were analyzed using a least-square procedure of SAS software (SAS®, Cary, North Carolina)and the significant differences of means were compared using the Tukey-Kramer test. The following three models were employed to analyze the reproductive traits. Model 1 was used to analyze age at first calving of heifers. The number of calving intervals and days opens till conception due to the effect of parity, and the year and season of calving on the traits were analyzed using model 2. Model 3 was used to analyze the number of services preconception using

Variable group 1: Year of birth,

1 1998-1999
2 2000-2001
3 2002-2003
4 2004-2005
5 2006-2007
6 2008-2009
7 2010-2011

Variable group 2: Insemination and Calving year

1 2000-2004
2 2005-2007
3 2008-2009
4 20010-2011
5 2012-2013

Variable group 4; Genetic group (blood level)

1. [50 - 62.5%]
2. (62.5 -75%]
3. (75 - 87.5%]
4. (87.5 - 93.3%]
5. >93.3

Variable group 3: Birth, Insemination and calving season

1 The long rainy season (June, July, Aug, Sep)
2 The short rainy season (March, April, May)
3 The long dry season (Oct, Nov, Dec, Jan, Feb)

Variable group 5: Parity of the cow

1. 1^{st} parity
2. 2^{nd} parity
3. 3^{rd} parity
4. 4^{th} and above

Models

Model 1. AFC: $y_{ijk} = \mu + B_i + S_j + G_k + e_{ijk}$

Model 2. DO and CI: $y_{ijklmn} = \mu + B_i + S_j + G_k + CS_l + CY_m + P_n + e_{ijklmn}$

Model 3. NSPC: $y_{ijklmn} = \mu + B_i + S_j + G_k + IS_l + IY_m + P_n + e_{ijklmn}$

Where:

μ = overall effect mean
B_i = the effect of i^{th} birth year
S_j = the effect of j^{th} season of birth
G_k = the effect of k^{th} genetic group
CS_l = the effect of l^{th} calving season
CY_m = the effect of m^{th} calving year
IS_l = the effect of l^{th} insemination season
IY_m = the effect of m^{th} insemination year
P_n = the effect of n^{th} parity
e_{ijklmn} = residue

additional parity, and year and season of insemination variables from model 1. The phenotype trend chart was analyzed using Microsoft spreadsheet software by taking the least square mean result of AFC, CI, DO, and NSPC on the y axis and the animal birth year to the x-axis. The levels of the different variables included in the different models were described below.

Result and Discussion

Age at first calving

The least-square mean of age at first calving of crossbred dairy cows was found 57.1 months (Table 1). The trait was significantly (P<0.01) influenced by the animals' birth year. The trait performance is recorded highest (65.4 months) in the year 1998-99 and thelowest AFC (34.9±0.20 months) in the herd was observed to heifers that have been born within the year 2010 to 2011. The birth year did show decreasing trend on this trait except in the year 2004-2005 that showed the highest AFC in the herd. However, the genotype and birth season did not show a significant effect on AFC.

This finding revealed a longer AFC of crossbred dairy cattle as compared to other reports. Negussie et al. have reported 30.2 months AFC of crossbred cattle, local Arsi, and other Zebu breeds born in the year 1968 to 1969 on the same farm(Negussie et al., 1998). The long-term crossbreeding and backcrossing of genotypes in the farm resulted in exotic blood levelsof more than 87.5%. This high exotic blood level requiresintensive animal management and husbandry practices to exploit their maximum genetic potential. Therefore, the higher AFC of crossbred dairy cows in the present report might be the reflection of inadequate management and the absence of selective breedingfollowing the exotic blood level. Besides, the nonsignificant difference of AFC across the different seasons might be due to similar cattle management regimes across the seasons. The nonsignificant difference of year and season of birth on the trait agreed with the report of Negussie et al (Negussie et al., 1998).

On station performance of crossbred dairy cattle in the central highland revealed lower AFC (40.2 months) (Demeke et al., 2004), 40.6 months (Mekonnin et al., 2015), and 42.5months (Effa et al., 2011) as compared to the present report. Significant differences of AFC from other reports were due to type of management, genotype, year of calving, and season of calving (Effa et al., 2011; Mekonnin et al., 2015), the difference in husbandry practices, input, and climatic variability (Wathes et al.,2014), where the farms are located. Other survey reports revealed that the AFC of crossbred dairy cattle under smallholder management system (34.8 months) in Arsi highland is much smaller than the present report while, in the central highland of Ethiopia the AFC of crossbred dairy cattle was reported 40.6 months (Shiferaw et al., 2003) still lower than the present report. The longer AFC of the present report might be due to the absence of directional selection, low management system, and lack of animal energy balance in the dairy farm (Haque et al.,2011; Masama et al., 2003).

Table 1. Least square mean and standard error of the mean of age at first calving of crossbred dairy heifers

Variables	Level	Age at First Calving
	Overall Mean	57.1±0.1
	cv	14.02
	N	210
Birth year		**
	1998-1999	65.4±0.26a
	2000-2001	62.9±0.30a
	2002-2003	65.9±0.25a
	2004-2005	71.6±0.27a
	2006-2007	59.6±0.13a
	2008-2009	44.3±0.18b
	2010-2011	34.9±0.20b
Birth Season		ns
	Long rainy season	55.6±0.14
	Long dry period	58.9±0.12
	Short rainy season	56.9±0.16
Genotype (exotic breed blood level)		ns
	[50 - 62.5%]	54.0±0.19
	(62.5 - 75%]	58.2±0.17
	(75 - 87.5%]	55.3±0.13
	(87.5 - 93.3%]	59.1±0.26
	> 93.3%	58.9±0.18

ns = non-significant difference, *P<0.05, **P<0.01

Calving interval

Calving interval is the period between two successive effective calving. The overall least square mean of CI of crossbred dairy cows in this study was422.2±0.22 days (Table 2). The trait varies with cow birth year (P<0.001), calving year (P<0.05), calving season (P<0.05),and parity

(P<0.001). Cows born in the year 1998-1999 and 2004-2005 had the longest CI, 550 and 562 days, respectively. Lower CI has been observed on cows born in the year 2006 to 2011. The significant effect of calving year in this study is in line with the findings of various reports (Demeke et al., 2004; Destaw & Kefyalew, 2018; Haile et al., 2009). The highest calving interval in this study was recorded in the year 2008-2009 (482.1 days) and 2012-2013 (481.1 days) whereas the lowest CI (350.1 days) was recorded for cows who gave birth in the year 2000-2004. Season of the cow born,and genotype did not show significant differences. Cows that have calved in the long rainy season (June to September) had the lowest CI (391.9 days), while cows that gave birth in the long dry period (October to February) had the longest CI (443.7 days). The lowest CIduring the long rainy season might be due to better pasture availability in the season.

The least-square mean indicated parity had (P<0.001) effect on the CI period. The CI was significantly longer between first and second parity (494.8 days) as compared to cows with parity four and above (Table 2). The present result agrees with the report of Haque et al.(Haque et al., 2011)and concluded that parity significantly influences CI (P<0.01).Conception rate is directly related to cows'physiological maturity, that is cow age(Khan, Uddin, & Royhan, 2015).The calving rate trend increased across parityin whichthe CI decrease from 494 months at firstparityto 367 days at parity 4 and above.

The least-square mean of the CI in this report was found to be lower than the report from different crossbred dairy cattle studies; 543 days (Hassan & Khan, 2013), 513 days (Belay, 2016), 462.8 days (Kebede, 2015), and469.45days (Kumar and Tkui 2014), and 450 days (Abraha et al., 2009). But the current result is equivalent to 435days (Haile et al., 2009),405.5 days (Mengistu et al., 2016), but and higher than 13 months (Niraj Kumar, Eshetie, Tesfaye, & Yizengaw, 2014) reported from a different dairy cattle farm in Ethiopia. The long CI is directly correlated to the number of services per conception and the length of days open till conception (Figure 1).

Table 2. Least square means and standard error of mean for calving interval and days open (days) of crossbred dairy cows

Variables	Level	Calving Interval	Days open
	Overall	422.2±0.4	131.4±0.6
	cv	9.8	28.3
	N	169	166
Cow birth year		***	***
	1998-1999	550.1±0.6a	276.6±1.1a
	2000-2001	383.4±0.6b	90.4±1.1b
	2002-2003	562.6±0.6a	284.9±1.1a
	2004-2005	402.9±0.8b	111.9±1.4ab
	2006-2007	376.8±0.7b	91.4±1.2b
	2008-2009	345.4±0.8b	69.9±1.4b
	2010-2011	361.1±0.9b	76.1±1.6b
Cow birth season		ns	ns
	Long rainy season	416.8±0.5	127.6±0.9
	Long dry period	441.6±0.5	147.8±0.8
	Short rainy season	408.5±0.5	119.5±0.8
Genotype (exotic blood level)		ns	ns
	[50 - 62.5%]	396.5±0.5	114.0±0.8
	(62.5 - 75%]	415.6±0.5	129.9±0.8
	(75 - 87.5%]	427.0±0.5	131.2±0.8
	(87.5 - 93.3%]	437.9±0.7	141.3±1.2
	>93.3%	434.7±0.6	141.5±1.0
Calving year		*	*
	<2005	350.1±1.1b	70.7±2.1b
	2005-2007	381.6±0.7b	98.9±1.3b
	2008-2009	482.1±0.6a	169.4±1.0a
	2010-2011	424.4±0.4a	145.3±0.7a
	2012-2013	481.1±0.4a	193.0±0.6a
Calving season		*	*
	Long rainy season	391.9±0.4b	101.6±0.7b
	Long dry period	443.7±0.4a	148.9±0.7a
	Short rainy season	431.9±0.5ab	146.4±0.9a
		***	**
parity	1st	494.8±0.3a	198.8±0.6a

	2nd	424.7±0.4b	141.4±0.7b
	3rd	397.7±0.5b	111.5±0.9b
	4th and above	376.1±0.7b	86.5±1.2b

ns = non-significant difference, *P<0.05, **P<0.01, ***P<0.001

Days open

Day's open is a period in which a cow remains empty between day of successfulcalving to the next conception. The result of crossbred dairy cows DO in the dairy farm and factors that influence the trait is depicted in Table 2. In this study, the least-square means of DO till conception was 131.4 days. The analysis revealed cow birth year, calving year, calving season, and parity significantly influence DO trait. Cows born in the year 2001-2002 to 2006-11 showed the lowest DO period (91.4 to 69.9 days) but higher (P<0.001) DO period was observed in the year 1998-1999 (276.6 days) and 2002-03 (284.9 days).

Days open till conception of a cow depends on the onset of postpartum estrus and the number of mating per conception.Factors,such as calving year and calving season significantly influence (P<0.05) DO period of the crossbred dairy cow. Cows gave birth in the year 2000-2005 in this study had the lowest DO (70.9 days) followed by the year 2005 to 2007, which is 98.9 days (Table 2). The highest DO observed from cows which gave birth in the year 2012 to 2013 (193 days). Similar to CI, cows that gave birth in the long rainy season significantly (P<0.05) had the lowest DO (101.6 days) as compared to the short rainy season (146.4 days) and long dry season (148.9 days). Cows at first parity had longer (P<0.01)DO (198.8 days) as compared to the advanced parity groups. The lowest DO (86.5 days)was recorded for cows of higher parity levels (four and above parities).The lower DO might be due to cow physiological maturity, whencow's age advances postpartum anestrous period decreases (Tanaka et al., 2008).

The least-square means of DO in this result was lower than a report from Jima town (5.19 months), southwest Ethiopia(Duguma, Kechero, & Janssens, 2012), 148 days at Holeta dairy farm (Tadesse et al., 2010), and 187 days from the central highland of Ethiopia (Lobago et al.,2006). The overall least square mean of the present result is higher than 114.2 days (Haque et al., 2011). A similar result,137.5 days, was reported in Mekele town, northern Ethiopia (Kumar & Tkui, 2014). The lower DO of the present report might be absence calf suckling on the cow that brought cows to postpartum estrus (Lobago et al., 2006) and successful artificial insemination, which was reported to 1.5 inseminations per conception.

Number service per conception

The number of services per conception is the number of times a cow is inseminated for a successful conception. The listed square mean and standard error of the NSPC is illustrated in Table 3. The overall least square mean of NSPC was 1.5 for a successful conception. The trait did not show a significant difference among birth year, birth season, the genotype of the cow, insemination year, and insemination season. Though the NSPC did not show a significant difference among the different birth years of the cow, it has indicated a decreasing trend of 2.1 in the year 1998-1999 to 1.3 in 2010-2011.

Table 3. Least square mean and standard error of the mean of NSPC of crossbred dairy cows

Variables	Levels	Number of Service per Conception
	Overall mean	1.5±0.1
	Cv	55.4
	N	272
Birth year		ns
	1998-1999	2.1±0.3
	2000-2001	1.8±0.2
	2002-2003	1.5±0.2
	2004-2005	1.2±0.3
	2006-2007	1.3±0.2
	2008-2009	1.2±0.2
	2010-2011	1.3±0.3
Birth season		ns
	Long rainy season	1.4±0.1
	Long dry period	1.5±0.1
	Short rainy season	1.5±0.1
Genetic group (exotic		ns

breed blood level)	50-62.5%	1.6±0.2
	62.5-75%	1.5±0.1
	75-87.5%	1.5±0.1
	87.5-93.3%	1.5±0.2
	>93.3%	1.3±0.2
Parity		Ns
	1st	1.7±0.1
	2nd	1.7±0.1
	3rd	1.5±0.2
	4th and above	1.3±0.2
Insemination year		Ns
	<2005	1.2±0.3
	2005-2007	1.2±0.2
	2008-2009	1.4±0.2
	2010-2011	1.8±0.1
	2012-2013	1.8±0.2
Insemination season		Ns
	Long rainy season	1.5±0.1
	Long dry period	1.6±0.1
	Short rainy season	1.4±0.1

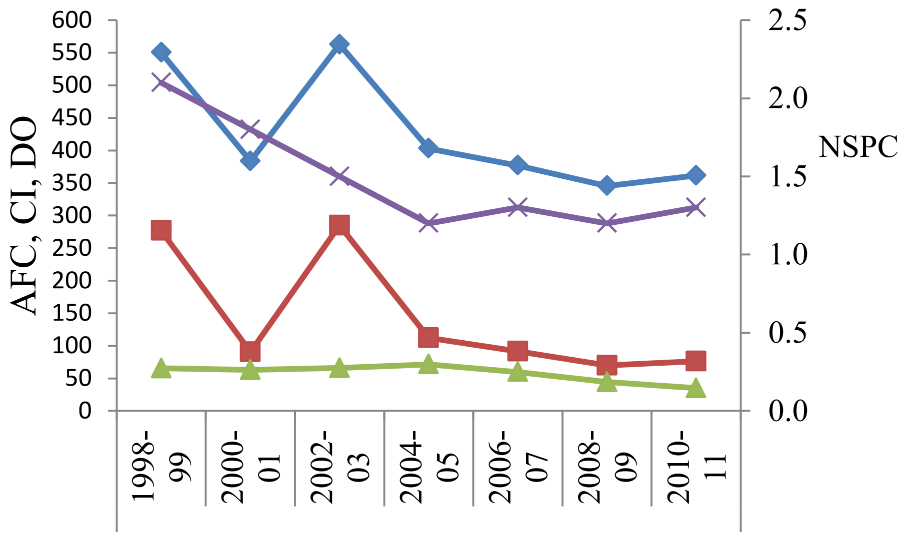
ns = non-significant difference,

The present study result revealed that the NSPC is similar to 1.52 reported on crossbred dairy cattle in Asella town, Ethiopia (Dinka, 2012), 1.52 in Bangladesh (Haque et al., 2011), 1.56 Jima town, Ethiopia (Duguma et al., 2012); 1.62 (Shiferaw et al., 2003) and 1.6 (Lobago et al., 2006) in the central highlands of Ethiopia and 1.67 in the mid rift valley of Ethiopia (Yifat et al., 2009). Higher NSPC (1.8) has been reported in Mekele town, north Ethiopia (Tadesse et al., 2010). Higher NSPC (2.3) has been reported from semi-intensive managed crossbred dairy cattle in the central highland of Ethiopia(Haile et al., 2009). However, NSPC did not show significant differences across the different factors and factors level in this study, several studies have reported that parity, year and season of insemination, and genotype of cow strongly influence the trait (Haque et al., 2011; Yifat et al., 2009). The non significant difference of the trait in this study might be due to adequate and consistent artificial insemination service management across seasons, years, and genotype. But the argument could not be conclusive since there could be several other possible factors.

Phenotype trends of some reproductive performances

The line chart (Figure 1) describes the phenotype trend of reproductive performance traits (AFC, CI, DO, and NSPC) across the animals' birth year (1998-2011). The AFC has shownvariation within the animal birth years; 65.4 months (1998-1999), 71.6 months (2004-2005) to 34.9 months (2010-2011). Though NSPC did not show significant difference along the animal birth year, the graphical trend shows a decreasing trend from 2.1 in the year 1998-1999 to 1.3 in the year 2010-2011. CI and DO showed the same trend throughout the cows' birth year. Lower CI and DO were recorded in the year 2000-2001 and showed an immediate increment in the year 2002-2003. After the year 2002-2003, the traits showed a decreasing trend. The irregular trend of the traits across birth year might be due to management and other environmental differences.The absence of directional selective breeding in the farm contributed to a higher disparity of the performance across the years. The irregular trait performance in the current study is in line with previous report (Mengistu et al., 2016).

Figure 1. Phenotype trends of reproductive performance of crossbred dairy cows across cows' birth year (1998 to 2011)



AFC=Age at first calving, CI=Calving interval, NSPC= Number of services per conception

Conclusion

The reproductive performances of crossbred dairy cattle in Ethiopia are lower as a result of various genetic and environmental factors. The difference between years and seasons in which the animal was born; year and season of the animal inseminated and gave birth, parity of the cow, the exotic blood level of the animal, and other non-genetic factors contributes to the variation in reproductive performances. The AFC of the present study was the highest as compared to different crossbred dairy cattle reproductive performances reported in the country. Variation in herd management, and feeding systemacross cow's birth year, calving year and calving season might contributed to the significant variation in CI and DO. However, CI, DO, and NSPC results indicate better reproductive performance of crossbred dairy cattle on the farm.The CI and DO are correlated traits, which both significantly affected by the birth year of the cow, calving year, and calving season of the cow and parity. Cows that calved in a good year and good season show lower CI and DO. However, exotic blood level content and season of cow born did not show a significant effect on both traits. The low NSPC contributed to low CI and DO as compared to other reports on the same traits but the NSPC in this study did show significant differences across the birth year, birth season, blood level, year and season of insemination, and parity.Therefore, to improve the reproductive performance of crossbred dairy cattle under semi-intensive management system, effective control of reproduction, husbandry,and feeding practices are necessary. Besides, well organized recording and database system enhance frequent reproductive performance evaluation and monitor genetic progress in the farm.

List of abbreviations

AFC Age at first calving

CI Calving interval

DO Days open

NSPC Number of services per conception

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References

Abraha, S.,Belihu, K., Bekana, M., & Lobago, F. (2009). Milk yield and reproductive performance of dairy cattle under smallholder management system in North-eastern Amhara Region, Ethiopia. *Tropical Animal Health &Production*, *41*(7), 1597–1604. https://doi.org/10.1007/s11250-009-9352-5

Ahmed, M. A. M., Ehui, S., & Assefa, Y. (2004). *Dairy Development in Ethiopia*. Washington, DC 20006 U.S.A.

Alemneh, T. (2019). Dairy Production in Ethiopia - Existing Scenario and Constraints. *Biomedical Journal of Scientific & Technical Research*, *16*(5). https://doi.org/10.26717/bjstr.2019.16.002903

Belay, D. L. (2016). A Review on Dairy Cattle Breeding Practices in Ethiopia. *Journal of Biology*, *6*(7), 121–128. https://doi.org/10.5897/IJLP2015.0276

Biscarini, F., Nicolazzi, E., Alessandra, S., Boettcher, P., & Gandini, G. (2015). Challenges and opportunities in genetic improvement of local livestock breeds. *Frontiers in Genetics*, *5*(JAN), 1–16. https://doi.org/10.3389/fgene.2015.00033

Demeke, S., Neser, F. W. C., & Schoeman, S. J. (2004). Estimates of genetic parameters for Boran, Friesian and crosses of Friesian and Jersey with the Boran cattle in the tropical highlands of Ethiopia: reproduction traits. *J. Anim. Breed. Genet*, *121*(1), 57–65. Retrieved from www.blackwell-synergy.com

Destaw, W. M., & Kefyalew, A. W. (2018). Evaluation of the reproductive performance of Holstein Friesian dairy cows in Alage ATVET college, Ethiopia. *International Journal of Livestock Production*, *9*(6), 131–139. https://doi.org/10.5897/ijlp2018.0469

Dinka, H. (2012). Reproductive performance of crossbred dairy cows under smallholder condition in Ethiopia. *International Journal of Livestock*

Production, *3*(3), 25–28. https://doi.org/10.5897/ijlp11.055

Diskin, M. G., & Kenny, D. A. (2014). Optimising reproductive performance of beef cows and replacement heifers. *Animal*, *8*(SUPPL. 1), 27–39. https://doi.org/10.1017/S175173111400086X

Duguma, B., Kechero, Y., & Janssens, G. P. J. (2012). Productive and reproductive performance of Zebu X Holstein-Friesian crossbred dairy cows in Jimma town, Oromia, Ethiopia. *Global Veterinaria*,*8*(1),67–72.

Effa, K., Wondatir, Z., Dessie, T., & Haile, A. (2011). Genetic and environmental trends in the long-term dairy cattle genetic improvement programmes in the central tropical highlands of Ethiopia. *Journal of Cell and Animal Biology*, *5*(6), 96–104. Retrieved from http://www.academicjournals.org/JCAB

Haile, A., Joshi, B. K., Ayalew, W., Tegegne, A., & Singh, A. (2009). Genetic evaluation of Ethiopian Boran cattle and their crosses with Holstein Friesian in central Ethiopia: Reproductive traits. *Journal of Agricultural Science*, *147*(1), 81–89. https://doi.org/10.1017/S0021859608008095

Haque, M. N., Haque, M. R., Parvin, A., & Hussain3, M. M. (2011). Productive and reproductive performance of different crossbred cattle at Sylhet Govt. Dairy farm. *Progress. Agric.*, *22*(40), 180–251.

Hassan, F., & Khan, M. S. (2013). Performance of crossbred dairy cattle at military dairy farms in Pakistan. *Journal of Animal and Plant Sciences*, *23*(3), 705–714.

Kebede, H. (2015). Productive and reproductive performance of holstein-friesian cows under farmer's management in Hossana town, Ethiopia. *International Journal of Dairy Science*, *10*(3), 126–133. https://doi.org/10.3923/ijds.2015.126.133

Khan, M., Uddin, J., & Royhan, G. (2015). Effect of age, parity and breed on conception rate and number of service per conception in artificially inseminated cows. *Bangladesh Livestock Journal. 2015*, *1*(January), 1–4. Retrieved from https://www.researchgate.net/publication/298422373

Kiwuwa, G. H., Trail, J. C. M., Kurtu, M. Y., Worku, G., Anderson, F. M., & Durkin, J. (1983). Crossbred dairy cattle productivity in Arsi Region, Ethiopia. *ILCA Research Report No. 11*, (11), 39. Retrieved from http://pdf.usaid.gov/pdf_docs/pnaap162.pdf

Kumar, N., & Tkui, K. (2014). Reproductive performance of crossbred dairy cows in Mekelle, Ethiopia. *Scientific Journal of Animal Science*, *3*(2), 35–40. Retrieved from https://www.cabdirect.org/cabdirect/abstract/20143111982

Kumar, Niraj, Eshetie, A., Tesfaye, A., & Yizengaw, H. A. (2014). Productive performance of indigenous and HF crossbred dairy cows in Gondar, Ethiopia. *Veterinary World*, *7*(3), 177–181. https://doi.org/10.14202/vetworld.2014.177-181

Lobago, F., Bekana, M., Gustafsson, H., & Kindahl, H. (2006). Reproductive performances of dairy cows in smallholder production system in Selalle, Central Ethiopia. *Tropical Animal Health and Production*, *38*(4), 333–342. https://doi.org/10.1007/s11250-006-4328-1

Masama, E., Kusina, N. T., Sibanda, S., & Majoni, C. (2003). Reproduction and lactational performance of cattle in a smallholder dairy system in Zimbabwe. *Tropical Animal Health and Production*, *35*(2), 117–129. https://doi.org/10.1023/A:1022821418031

Mekonnin, A. B., Harlow, C. R., Gidey, G., Tadesse, D., Desta, G., Gugssa, T., & Riley, S. C. (2015). Assessment of Reproductive Performance and Problems in Crossbred (Holstein Friesian X Zebu) Dairy Cattle in and Around Mekelle, Tigray, Ethiopia. *Animal and Veterinary Sciences*, *3*(3), 94. https://doi.org/10.11648/j.avs.20150303.14

Mengistu, D. W., Wondimagegn, K. A., & Demisash, M. H. (2016). Reproductive performance evaluation of holstein friesian and their crosses with boran cattle breeds in ardaita agricultural technical vocational education training college dairy farm, Oromia Region, Ethiopia. *Iranian Journal of Applied Animal Science*, *6*(4), 805–814.

Negussie, E., Brännäng, E., Banjaw, K., & Rottmann, O. J. (1998). Reproductive performance of dairy cattle at Asella livestock farm, Arsi, Ethiopia. I: Indigenous cows versus their F1 crosses. *Journal of Animal Breeding and Genetics*, *115*(1–6), 267–280. https://doi.org/10.1111/j.1439-0388.1998.tb00348.x

Shiferaw, Y., Tenhagen, B. A., Bekana, M., & Kassa, T. (2003). Reproductive Performance of Crossbred Dairy Cows in Different Production Systems in the Central Highlands of Ethiopia. *Tropical Animal Health and Production*, *35*(6), 551–561. https://doi.org/10.1023/A:1027377722576

Sørensen, M. K. (2000). Crossbreeding – An Important Part of Sustainable Breeding in Dairy Cattle and Possibilities for Implementation, 29–40.

Staal, S. J., Pratt, A. N., & Jabbar, M. (2008). Dairy Development for the Resource Poor Part 2: Kenya and Ethiopia Dairy Development Case Studies. *Pro-Poor Livestock Policy Intiative*, (44), 67. Retrieved from http://www.fao.org/ag/againfo/programmes/en/pp/docarc/wp44_2.pdf

Tadesse, M., Thiengtham, J., Pinyopummin, A., & Prasanpanich, S. (2010). Productive and reproductive performance of holstein friesian dairy cows in Ethiopia. *Livestock Research for Rural Development*, *22*(2), 34. Retrieved from https://lrrd.cipav.org.co/lrrd22/2/tade22034.htm

Tanaka, T., Arai, M., Ohtani, S., Uemura, S., Kuroiwa, T., Kim, S., & Kamomae, H. (2008). Influence of parity on follicular dynamics and resumption of ovarian cycle in postpartum dairy cows. *Animal Reproduction Science*, *108*(1–2), 134–143. https://doi.org/10.1016/j.anireprosci.2007.07.013

Wathes, D. C., Pollott, G. E., Johnson, K. F., Richardson, H., & Cooke, J. S. (2014). Heifer fertility and carry over consequences for life time production in dairy and beef cattle. *Animal*, *8*(SUPPL. 1), 91–104. https://doi.org/10.1017/S1751731114000755

Yifat, D., Kelay, B., Bekana, M., Lobago, F., Gustafsson, H., & Kindahl, H. (2009). Study on reproductive performance of crossbred dairy cattle under smallholder conditions in and around Zeway, Ethiopia. https://doi.org/http://www.lrrd.org/lrrd21/6/cont2106.htm

Yigezu, Z., (2000). DDE's Experience in milk collection, processing and marketing. The Role of Village Dairy Co-operatives in Dairy Development. Smallholder Dairy Development Project (SDDP) Proceeding, Ministry of Agriculture (MOA). Addis Ababa, Ethiopia.