Reproductive and productive performance of Zebu × Holstein-Friesian crossbred dairy cows in and around Sendafa town, Oromia Region, Ethiopia

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ABSTRACT

The research aimed to investigate the reproductive and productive performances of crossbred dairy cows in and around Sendafa town, Oromia region, Ethiopia. For the survey, 156 (78 from urban area and 78 from peri-urban area) respondents which had crossbred dairy cows were selected. For the monitoring study, a total of 24 dairy farms and from which 180 crossbred dairy cows were purposefully selected, i.e., 60 from large scale, 60 from medium scale, and 60 from small scale. The findings revealed that the average age at first service of crossbred dairy heifers was 21.5±1.5 months for large, 22.1±1.2 for medium, and 23.9±1.5 for small-scale production in urban dairy farms and 22.2±2.4 months for large, 22.7±2.5 for medium, and 24.8±2.1 for small-scale production in peri-urban dairy farms. The average age at first calving was 32.6±2.8 months for large, 33.0±2.1 for medium, and 32.7±2.7 small-scale production in urban dairy farms and 33.7±3.8 months for large, 33.4±3.0 for medium, and 34.5±3.1 for small-scale production in peri-urban dairy farms. The overall numbers of services per conception for crossbred dairy cows was 1.6± 0.6 for urban and 1.6±0.8 for peri-urban production systems. The findings revealed that days open for different genotype levels of crossbred dairy cows varied across production systems. According to the monitoring results, crossbred dairy cows with genotype levels of 25%, 50%, 75%, and >75% produced an average daily milk yield of 7.2±1.0, 8.9±1.2, 11.5±2.4 and 12.7±2.3 litres per day in urban dairy farms and 8.2±0.8, 8.5±0.5, 9.7±1.4 and 11.5±3.6 litres per day in peri-urban dairy farms, respectively. The average daily milk yield was increased from parity one to parity four, then decreased to parity five across all production scales and systems. The overall lactation length for all genotype levels was 323.0±46.7 days for urban and 319.0±45.6 days for peri-urban production systems. It is concluded that the crossbred cows' age at first service, age at first calving, days open, and calving interval are all longer, and the milk yield also does not match to their milking potential. As a result, it is recommended that crossbred dairy cows' reproductive and productive performances be enhanced by improving the farm management practises.

Keywords: Crossbred dairy cows; Milk yield; Reproductive performance; Ethiopia.
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INTRODUCTION

Ethiopia is thought to have the largest livestock population in Africa, with an estimated 70 million cattle. Female cattle account for approximately 56% of the total cow population, with male cattle accounting for the remaining 44% (CSA, 2021). Despite the fact that indigenous dairy cattle make up the majority of the dairy cattle population, milk

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yield per cow is very low, but crossbred cows produce more milk per cow (CSA, 2021). As a result, Ethiopia has implemented a crossbreeding program as a strategy to increase milk production per cow (Aynalem Haile *et al*., 2011).

Dairy cattle productivity, such as daily milk, lactation yield, and lactation length, as well as reproductive performance, such as age at first service, age at first calving, calving interval, days open, and number of services per conception, are important traits for the dairy industry's profitability. Reproductive performance is one of the major determinant of dairy cattle productivity (Berry *et al*., 2014) and failure to reach sexual maturity at a young age, a later age at first calving, an increased number of services per conception, longer calving intervals, and a large loss of valuable productive animals are all major causes of reproductive loss in cattle (Shiferaw Yoseph *et al*., 2005). According to Bayrau Girmay and Berihu Gebrekidan's (2014) report, the overall early, mid, and late milk yields of crossbred dairy cows were 12.09±3.42, 9.73±3.12, and 7.04±2.84 litres per day/cow, respectively. Feed, genetics, illnesses, and management techniques all have an impact on dairy cattle productivity and reproduction (Dobson *et al*., 2007). Even though Ethiopian farmers have been using crossbred cattle, particularly zebu and Holstein-Friesian cattle to boost milk output for many years, the development of effective breeding techniques is dependent on a precise evaluation of the performance of crossbred cows. To understand performance under current management approaches, it is critical to continuously analyse the success of dairy production in general, and crossbreeding programs in particular, because many factors influence crossbred cattle performance (Getahun Kefyale *et al*., 2020).

The livestock production systems are highly dynamic due to the influences of various drivers of change. Moreover, the status of milk production and reproductive performance of crossbred dairy cows in Ethiopia in general, and in the study area in particular, has not been thoroughly researched and documented. Therefore, the aim of this study was to investigate the reproductive and productive performances of crossbred dairy cows in and around Sendafa town, Oromia region, Ethiopia

MATERIALS AND METHODS

Description of the study area

The study was conducted in and around Sendafa town, Oromia region, Ethiopia. It is located 38 kilometres northeast of Addis Ababa (Figure 1). The study area is located between 9˚06'14"to 9˚10'30" North latitude and 38˚57'60" to 39˚04'53" East longitude, with an elevation of 2514 meters above sea level.

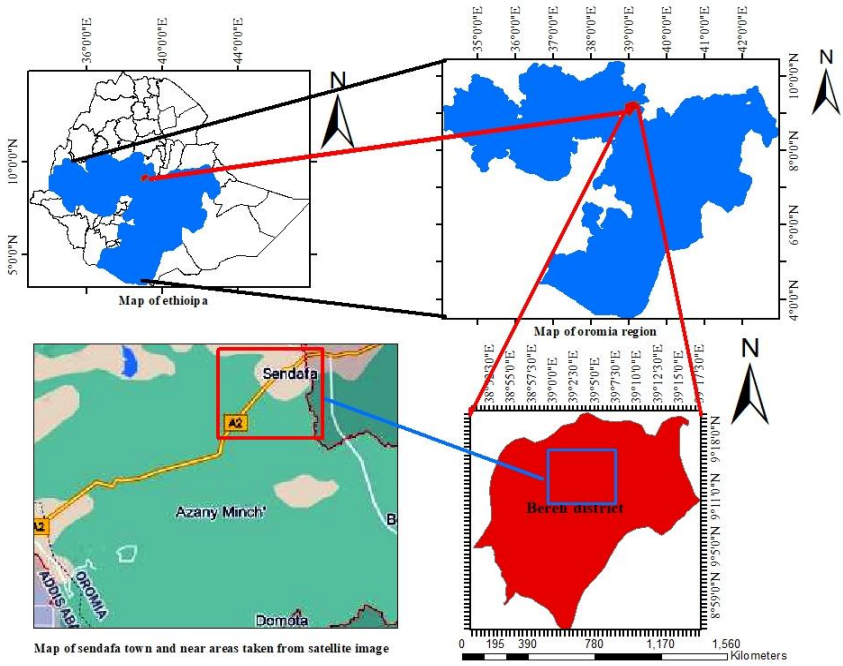

Figure 1. Map of the study area

Data collection methods

Survey

The study area was chosen purposefully for its market-oriented dairy development potential. The sampling frame included milk producers/farmers in urban and peri-urban areas who owned crossbred dairy cattle. Six kebeles were purposefully chosen based on their dairy production potential and possession of crossbred dairy cows (three from urban and three from peri-urban areas). For the survey, 156 people were chosen at random (78 from the urban and 78 from the peri-urban). To collect survey data, a pre-tested semi-structured questionnaire was used. Age at first service, age at first calving, numbers of services per conception, days open, calving interval, daily milk yield, and lactation length are among the data collected. Arsham's (2002) formula was used to calculate the sample size for the household survey:

$$N = \frac{0.25}{SE^2}$$

Where, N = sample size; SE = standard error of the population. Smallholder farmers were selected at 4% standard error by random sampling method.

$$N = \frac{0.25}{(0.04)^2} = \frac{0.25}{0.0016} = 156$$

Monitoring

To assess the milk yield of crossbred dairy cows, farms were divided into three production scales: small (farms with fewer than ten dairy cows), medium (farms with 11 to 20 dairy cows), and large (farms with more than 21 dairy cows) (Seble Aweke and Berhanu Mekibib, 2017). The study population includes 24 dairy cow farms, each with 180 Zebu × Holstein Friesian dairy cows (45 cows from each genotype level). The exotic genotype of crossbred cows was known based on information obtained from owners. The milk yield was measured for 10 months. Milk yield was calculated by weighing milk from each cow in the morning and evening. Morning and evening milk data were combined to calculate daily milk yield. By adding daily yields, total lactation milk yields for 305 days were calculated.

Data analysis

Data on the reproductive and milk production performances (daily milk yield, lactation milk yield, and total milk yield) of Zebu × Holstein-Friesian dairy cows were analysed using the General Linear Model (SPSS, version 24). Mean separations were done using the Tukey's range test for variables whose F-values declared a significant difference. The level of significance was set at $p < 0.05$. The two statistical models listed below were used to analyse reproductive and productive performance.

Analytical model used for reproductive performance:

$Y_{ijk} = \mu + B_i + Kj + S_k + \varepsilon_{ijk}$
Where: Y_{ijk} = dependent variable, μ= Overall mean, B_i= the effect of i^{th} genotype levels (1, 2, 3, 4), K_j = the effect of j^{th} production system (1, 2), S_k= the effect of k^{th} farm size (production scale 1, 2, 3), E_{ijk}= random residual error term

Analytical model used for production performance: $Y_{ijkl}=u+ B_i+ S_j+ P_k+S_l +e_{ijkl}$
Where: Y_{ijkl}=response variable, u = overall mean, B_i= the effect of i^{th} genotype levels (1, 2, 3, 4), S_j= the effect of j^{th} stage of lactation (1, 2, 3), P_k= the effect of k^{th} parity (1, 2, 3, 4, 5), $S_{l=}$ the effect of l^{th} production systems (1, 2), e_{ijkl}= random residual error term.

RESULTS AND DISCUSSION

Reproductive performance of crossbred dairy cows

Age at first service (AFS)

Age at first service is defined as the age at which heifers attain body condition and sexual maturity for accepting service for the first time. In the urban production system, the average age at first service of crossbred dairy heifers for large, medium, and small-

scale production were 21.5±1.5, 22.1±1.2 and 23.9±1.5 months, respectively. The average age at first service of crossbred dairy heifers in large, medium, and small-scale production in the peri-urban production system were 22.2±2.4, 22.7±2.5 and 24.8±2.1 months, respectively (Table 1). The age at first service were varied among genotype levels and was shorter in urban than peri-urban production systems. This may be due to differences in genotype levels, nutrition, and management practices among production systems and the scale of production. This finding is in agreement with Tarekegn Demeke's (2020) who stated that the average age at first service of crossbred dairy heifers in Angot District, North Wolo Zone was 23.41±1.54 months. Besides, Zewdie Wondatir (2010) reported as age at first service for crossbred dairy heifers in Ethiopia's highlands and central rift valley were 24.3 and 27.5 months, respectively. The results, on the other hand, were higher than those of Nibret Moges (2012), who reported a mean AFS of 15.4 months for crossbred dairy heifers in Gondar's urban and peri-urban areas.

Number of services per conception (NSPC)

The number of services per conception is defined as the number of services required for a successful conception. The average numbers of services per conception in the urban dairy production system for large, medium, and small-scale farms in this study were 1.6±0.5, 1.6±0.6 and 1.8±0.6, respectively. The number of services per conception for 25% and >75% genotype levels was significant at ($p < 0.001$). The average numbers of services per conception for large, medium, and small-scale farms in peri-urban areas were 1.7±0.7, 1.7±0.8 and 2.0±0.9, respectively (Table 1). The number of services per conception was varied in the current study among crossbred dairy cows of different genotype levels in different production systems. These could be the result of ineffective and slow heat detection, as well as the unwillingness of the Artificial Insemination (AI) technician. In this regard, Amare Berhe *et al*. (2019) reported that the average number of services per conception for crossbred dairy cows is 1.7±0.59. This finding is consistent with the findings of Haftu Kebede (2015), who reported that the average service per conception is 1.8±0.0.09 in Hossana town, Ethiopia.

Age at first calving (AFC)

Age at first calving is defined as the age at which heifers calve for the first time. In the urban production system, the ages at first calving for large, medium, and small-scale production were 32.6±2.8, 33.0±2.1 and 32.7±2.7 months, respectively. The overall mean of age at first calving in the urban production system was 32.8±2.5 months, and the mean age at first calving in the peri-urban production system was 33.7±3.8, 33.4±3.0 and 34.5±3.1 months, respectively. In the peri-urban production system, the average length of the first calving was 33.9±3.3 months (Table 1). In different scales of production systems, the mean length of age at first calving is highly significant at ($p < 0.001$) for the genotype levels of 25% and >75%. This finding is in agreement with Hunduma Dinka's (2012) findings whose average age at first calving for crossbreds was

31.9±0.22 months in Ziway. The average age at first calving in the current study was higher than the 29.52 months reported by Tadesse Senay *et al.* (2014) for crossbreed cows in Debra Tabor town.

Days open (DO)

Days open is defined as the interval from calving to the day of conception, which includes the postpartum anoestrous interval and service period. The number of days open for different genotype levels of crossbred dairy cows in different production systems varied and were 118.5±24.1, 122.1±24.0 and 134.0±22.3 days in urban for large, medium, and small-scale production systems, respectively. The average length of day opens in the peri-urban production system for large, medium, and small-scale production systems were 137.4±21.5, 139.3±22.4 and 149.3±25.0 days, respectively, with an overall average days open length of 142.0±23.0 days. An overall increase in days open was observed in small scale dairy production, both in urban and peri-urban areas. This could be due to the inconsistency of management related to a lack of supplementary feed, poor oestrus detection, insufficient AI services, a lack of regular follow up of breeder cows, and other technical issues (Table 1). These findings validate the previous findings of Million Tadesse *et al*. (2010), who reported that the average length of days open in crossbred dairy cows in Addis Abeba's urban and peri-urban dairy production systems was 148±1.72 days.

Calving interval (CI)

Calving interval is defined as the period of time between successive calving. The calving interval of crossbred dairy cows was statistically significant ($p < 0.05$) among different production systems in the current study. The average calving interval was longer in this study, which could be attributed to poor nutritional status, poor breeding management, a lack of own bull and artificial insemination service, longer days open, diseases, and poor management practices. The mean length of the calving interval in the urban production system for large, medium, and small-scale production were 15.3±1.7, 15.7±1.9 and 17.3±1.5 months, respectively. In the urban production system, the average calving interval was 15.7±1.7 months. The mean lengths of calving intervals in peri-urban production for large, medium, and small-scale production were 15.4±1.6, 16.1±1.4 and 16.7±1.7 months, respectively. In the peri-urban production system, the overall mean length of the calving interval was 16.1±1.6 months (Table 1). The current study's average calving intervals were higher than the results of Hunduma Dinka (2012), who reported that the CI of crossbred cattle in and around Gondar is 372.8 days and 13.4 ±5.1 months (Nibret Moges, 2012). However, it is less than the findings of Belay Duguma *et al*. (2012), who reported that the CI in Zebu × Holstein-Friesian crossbred dairy cows in Jimma town, is 21.36±3.84 months.

Table 1. Reproductive performance of crossbred dairy cows in the study areas (Mean±SD)

		Genotype levels				Overall
Production system	**Scale of production**	**25%**	**50%**	**75%**	**>75 %**	
Age at first service						
Urban	Large	25.6±0.7^{b}	21.8±2.4^{a}	19.1±1.2^{b}	19.3±1.5^{a}	21.5±1.5^{b}
	Medium	25.0±0.6^{b}	23.3±1.1^{a}	19.8±1.1^{b}	20.2±1.8^{a}	22.1±1.2^{b}
	Small	27.6±0.8^{a}	24.4±2.7^{a}	22.6±1.5^{a}	21.3±1.1^{a}	23.9±1.5^{a}
	Subtotal	26.1±0.7^{a}	23.2±2.1^{a}	20.5±1.3^{ab}	20.3±1.5^{a}	22.5±1.4^{b}
Peri-urban	Large	25.1±3.0^{b}	21.3±2.0^{b}	22.8±3.1^{a}	19.4±1.4^{b}	22.2±2.4^{b}
	Medium	26.0±2.2^{b}	23.0±2.0^{b}	21.6±3.5^{a}	20.3±2.3^{b}	22.7±2.5^{b}
	Small	28.2±2.2^{a}	25.0±1.4^{a}	23.0±2.4^{a}	22.8±2.5^{a}	24.8±2.1^{a}
	Subtotal	26.4±2.3^{b}	23.1±1.8^{b}	22.5±2.7^{a}	20.8±2.1^{b}	23.2±2.3^{ab}
Overall		26.3±1.5^{b}	23.1±1.9^{b}	21.5±2.0^{ab}	20.5±1.8^{b}	22.8±1.8^{b}
	P- value	0.036	0.022	0.006	0.006	
Number of services per conceptions						
Urban	Large	2.3±0.5^{a}	1.7±0.5^{b}	1.2±0.4^{c}	1.4±0.7^{c}	1.6±0.5^{b}
	Medium	1.6±0.9^{b}	1.4±0.5^{c}	1.8±0.4^{a}	1.6±0.5^{b}	1.6±0.6^{b}
	Small	1.7±0.7^{b}	2.0±0.8^{a}	1.6±0.5^{b}	1.8±0.4^{a}	1.8±0.6^{a}
	Sub total	1.9±0.7^{ab}	1.7±0.6^{b}	1.5±0.4^{b}	1.6±0.5^{b}	1.6±0.6^{b}
Peri-urban	Large	1.6±0.7^{b}	1.8±0.4^{a}	1.6±0.9^{b}	1.8±0.7^{a}	1.7±0.7^{b}
	Medium	1.9±0.8^{b}	2.0±1.0^{a}	1.5±0.7^{b}	1.6±0.6^{b}	1.7±0.8^{b}
	Small	2.0±1.0^{a}	1.9±1.1^{a}	2.2±1.0^{a}	1.9±0.5^{a}	2.0±0.9^{a}
	Subtotal	1.5±0.8^{b}	1.9±1.0^{a}	1.8±0.8^{b}	1.8±0.6^{a}	1.8±0.8^{b}
Overall		1.5±0.7^{b}	1.7±0.8^{b}	1.6±0.8^{b}	1.6±0.7^{b}	1.6±0.8^{b}
	P- value	0.001	0.006	0.012	0.001	
Age at first calving						
Urban	Large	32.5±2.9^{b}	33.1±4.2^{a}	32.8±1.8^{a}	31.9±2.2^{a}	32.6±2.8^{a}
	Medium	35.8±2.5^{a}	33.9±1.8^{a}	31.7±2.5^{a}	31.4±1.7^{a}	33.0±2.1^{a}
	Small	36.3±3.2^{a}	34.6±2.7^{a}	33.4±2.4^{a}	33.4±2.5^{a}	32.7±2.7^{a}
	Subtotal	34.9±2.9^{a}	33.8±2.9^{a}	32.6±2.2^{a}	31.6±2.1^{a}	32.8±2.5^{a}
Peri-urban	Large	34.6±4.6^{b}	34.8±4.3^{b}	34.4±2.2^{b}	30.9±1.9^{b}	33.7±3.8^{b}
	Medium	36.0±3.9^{a}	33.6±3.0 ^{b}	32.8±2.7^{b}	31.3±2.3^{ab}	33.4±3.0^{a}
	Small	35.0±4.5^{a}	35.1±3.1^{a}	35.7±2.2^{a}	32.2±2.6^{a}	34.5±3.1^{b}
	Subtotal	35.2±4.3^{a}	34.5±3.5^{b}	34.3±2.4^{b}	31.5±2.3^{ab}	33.9±3.3^{a}
Overall		35.4±3.9^{a}	34.4±3.5^{b}	32.6±2.4^{b}	32.2±2.2^{a}	33.5±3.4^{a}
	P- value	0.000	0.036	0.036	0.000	
Day opens						
Urban	Large	118±20^{b}	130±31^{b}	114±22^{b}	112±23^{a}	119±24^{b}
	Medium	140±28^{a}	125±32^{b}	110±13^{b}	114±24^{a}	122±24^{b}
	Small	136±26^{a}	142±30^{a}	140±16^{a}	118±18^{a}	134±22^{a}
	Subtotal	131±15^{ab}	132±31^{b}	121±17^{b}	115±22^{a}	125±24^{b}
Peri-urban	Large	141±32^{b}	150±24^{a}	135±13^{a}	122±18^{a}	137±22^{b}
	Medium	147±25^{b}	139±17^{a}	141±22^{a}	131±26^{b}	139±22^{b}
	Small	160±20^{a}	143±20^{a}	157±35^{a}	137±26^{b}	149±25^{a}
	Sub total	149±26^{a}	144±20^{a}	144±24^{a}	130±23^{b}	142±23^{b}
Overall		137±27^{ab}	140±28^{a}	130±25^{a}	129±24^{b}	134±26^{b}
	P- value	0.048	0.05	0.05	0.054	

Calving interval						
Urban	Large	14.3±1.3^{b}	14.1±2.0^{b}	17.0±2.0^{a}	15.9±1.6^{b}	15.3±1.7^{b}
	Medium	15.0±1.4^{a}	15.1±1.6^{a}	16.8±1.5^{b}	16.0±3.0^{b}	15.7±1.9^{b}
	Small	15.8±1.5^{a}	15.5±1.5^{a}	18.8±1.1^{a}	19.1±2.0^{a}	17.3±1.5^{a}
	Subtotal	15.0±1.4^{a}	14.9±1.4^{b}	17.5±1.5^{a}	17.0±2.2^{a}	15.7±1.7^{b}
Peri-urban	Large	14.5±1.6^{b}	16.3±2.2^{b}	15.1±1.7^{b}	15.9±1.2^{b}	15.4±1.6^{a}
	Medium	15.4±0.5^{ab}	16.8±2.2^{b}	16.1±1.8^{a}	16.1±1.1^{b}	16.1±1.4^{a}
	Small	16.4±1.3^{a}	16.0±0.8^{b}	16.4±1.9^{a}	18.2±2.1^{a}	16.7±1.7^{a}
	Subtotal	15.4±1.1^{ab}	16.4±1.7^{b}	15.9±1.8^{a}	16.7±1.8^{b}	16.1±1.6^{a}
	Overall	15.2±1.3^{a}	15.6±1.5^{b}	16.7±1.6^{a}	16.8±2.0^{b}	15.9±1.6^{a}
	P- value	0.022	0.026	0.026	0.000	

Note: Means with the same letter of superscript in the same column did not differ significantly at ($p < 0.05$), N= Number of sampled dairy cows (45 cows from each blood level) SD = Standard deviation

Productive performance of crossbred dairy cows

Effect of stage of lactation on milk yield

The mean daily milk yields of crossbred dairy cows in the study area were varied, and they increased as the genotype levels increased in various types of production systems, production scale, and stage of lactation. Accordingly, the average daily milk yield in an urban production system for large, medium, and small-scale dairy farms with 25%, 50%, 75%, and >75% genotype levels were 7.2±1.0, 8.9±1.2, 11.5±2.4 and 12.7±2.3 litres, respectively. In urban, the average daily milk yield of all genotype levels was 10.1±1.7 litres of milk per cow per day. The average daily milk yields in large, medium, and small-scale dairy production systems in 25 percent, 50 percent, 75 percent, and >75 percent genotype levels were 7.8±1.1, 8.3±0.9, 11.2±2.0 and 13.0±2.6 litres, respectively. Total milk yields in urban and per urban dairy production in large, medium, and small-scale dairy farms were 10.1±1.7 and 10.1±1.9 litres per day per cow, respectively (Table 2).

This result was significantly ($p < 0.000$) varied for genotype levels greater than 75% across all production scales. This result was higher than Adebabay Kebede's (2009) findings, who stated that the average daily milk production of crossbred cows in Ethiopia is 8 litres, but lower than previous reports by Niraj *et al*. (2014), who stated that 12.15±0.82 litres in HF crossbred dairy cows maintained under farmers' management systems. The finding of Belay Duguma (2020) also revealed a lower daily milk yield (6.0 ± 0.33) for crossbred cows in selected towns of Jimma Zone, Ethiopia. Lower milk yields can be attributed to a variety of factors, including feeding and other management practices.

Table 2. Effect of lactation on daily milk yield of crossbred dairy cows in the study areas (Mean±SD)

Production system	Scale of production	Stage of lactation	Genotype levels				Overall
			25% (N=45)	50% (N=45)	75% (N=45)	>75% (N=45)	
Urban	Large	1st	10.0±1.6[a]	12.0±2.9[a]	14.7±3.6[a]	17.8±2.6[a]	13.6±2.6[a]
		2nd	7.7±1.7[a]	9.4±2.1[a]	11.4±3.8[b]	15.1±2.4[a]	10.9±2.5[a]
		3rd	5.2±1.1[a]	6.7±1.0[b]	8.6±3.0[b]	9.8±2.2[b]	7.6±1.8[b]
		Subtotal	7.6±1.4[a]	9.4±1.9[a]	11.6±3.4[b]	14.2±2.3[ab]	10.7±2.2[a]
	Medium	1st	9.5±1.5[a]	11.0±1.9[a]	13.4±2.3[a]	15.3±2.7[a]	12.3±2.1[a]
		2nd	7.5±1.1[a]	8.1±1.4[b]	11.3±2.7[b]	13.3±2.1[b]	10.1±1.8[b]
		3rd	4.9±0.9[b]	5.1±0.8[b]	7.1±1.4[b]	8.6±2.0[b]	6.4±1.3[b]
		Sub total	7.3±1.0[a]	8.1±1.2[b]	10.6±2.1[b]	12.4±2.2[b]	9.5±1.6[b]
	Small	1st	8.6±0.9[a]	12.1±0.8[a]	15.8±2.4[a]	14.4±3.1[a]	12.7±1.8[a]
		2nd	7.1±1.1[a]	9.3±0.6[a]	12.9±2.2[b]	12.4±2.8[b]	10.4±1.7[a]
		3rd	4.6±0.6[b]	6.6±0.5[b]	8.0±1.5[c]	8.1±1.8[b]	6.6±1.1[b]
		Subtotal	6.7±0.7[a]	9.3±0.4[a]	12.2±1.9[b]	11.6±2.5[b]	9.9±1.4[a]
	Overall		7.2±1.0[a]	8.9±1.2[a]	11.5±2.4[b]	12.7±2.3[b]	10.1±1.7[a]
	P-value		0.002	0.016	0.004	0.000	
Peri-urban	Large	1st	9.4±1.3[a]	11.0±2.6[a]	14.7±2.1[a]	17.9±2.5[a]	13.2±2.1[a]
		2nd	7.7±1.3[a]	8.4±2.1[a]	12.2±2.2[b]	15.1±2.8[a]	10.8±2.2[b]
		3rd	5.3±1.2[b]	5.5±0.8[a]	9.3±1.9[b]	10.2±2.7[b]	7.6±1.6[b]
		Subtotal	7.5±1.1[a]	8.3±1.7[a]	11.4±1.9[b]	14.0±2.5[c]	10.6±1.8
	Medium	1st	10.3±1.7[a]	11.3±1.2[a]	14.9±2.9[a]	16.5±2.7[a]	13.3±2.1[a]
		2nd	7.9±1.3[a]	8.3±0.6[a]	12.8±3.1[b]	13.9±2.4[b]	10.7±1.8[a]
		3rd	5.8±1.3[b]	5.6±0.0[b]	9.4±2.4[b]	9.9±1.4[c]	7.7±1.3[b]
		Subtotal	7.6±1.4[a]	8.1±0.5[a]	12.4±2.7[b]	13.4±1.9[b]	10.6±1.6[a]
	Small	1st	9.7±0.8[a]	10.0±1.1[a]	12.8±1.8[a]	14.0±4.1[a]	11.6±1.9[a]
		2nd	8.6±1.2[a]	9.3±0.7[a]	9.9±1.5[b]	12.1±4.1[a]	10.0±1.9[a]
		3rd	6.4±0.5[b]	6.2±0.4[b]	6.5±1.4[b]	8.3±2.8[b]	6.9±1.3[b]
		Subtotal	8.2±0.8[a]	8.5±0.5[a]	9.7±1.4[a]	11.5±3.6[a]	10.1±1.6[a]
		Overall	7.8±1.1[a]	8.3±0.9[a]	11.2±2.0[a]	13.0±2.6[a]	10.4±1.9[a]
	P-value		0.000	0.001	0.001	0.001	

Note: Means with the same letter of superscript in the same column did not differ significantly at ($p < 0.05$, N= Number of sampled dairy cows (45 cows from each blood level) SD = Standard deviation

Effect of parity on milk yield

The average daily milk yield was increased from parity one to parity four in the current study, then decreased to parity five across all production scales and urban and peri-urban production systems. Overall daily milk yields of crossbred dairy cows in urban areas for parity one, parity two, parity three, parity four, and parity five were 8.6±1.7, 10.6±2.0, 11.4±1.9, 11.5±2.0 and 9.9±2.0 litres, respectively. Whereas, in peri-urban areas for parity one, parity two, parity three, parity four, and parity five were 6.9±0.7, 8.1±1.0, 9.8±2.0, 9.2±1.6 and 8.3±1.5 litres, respectively (Table 3).

Table 3. Effect of parity on milk production of crossbred dairy cows in the study areas (N=180) (Mean±SD).

Production system	Stage of lactation	Parity					Overall
		1st	2nd	3rd	4th	5th	
Urban							
Large scale	1st	10.9±2.8^{a}	14.1±2.2^{a}	16.1±2.0^{a}	17.2±2.4^{a}	13.0±1.9^{a}	14.3±2.7^{a}
	2nd	9.1±2.2^{a}	10.6±1.3^{b}	12.3±1.5^{b}	13.4±2.0^{b}	9.7±1.4^{a}	11.0±1.7^{b}
	3rd	5.5±0.8^{b}	6.4±1.1^{c}	7.3±2.7^{c}	8.3±1.6^{c}	6.1±1.4^{a}	6.7±1.4^{c}
	Subtotal	8.5±1.8^{ab}	10.4±1.5^{b}	11.9±2.1^{b}	13.0±2.0^{b}	9.6±1.6^{a}	10.7±1.8^{b}
Medium scale	1st	12.1±1.3^{a}	14.9±1.5^{a}	16.0±1.3^{a}	15.3±2.0^{a}	13.4±1.6^{a}	14.5±1.3^{a}
	2nd	10.0±2.2^{a}	11.7±3.0^{b}	12.0±2.3^{b}	12.4±2.0^{a}	11.2±2.4^{a}	11.6±2.2^{a}
	3rd	6.5±1.3^{b}	7.2±2.1^{c}	8.2±1.8^{c}	7.6±2.5^{b}	6.8±2.2^{b}	7.2±2.0^{b}
	Subtotal	9.5±1.6^{a}	11.3±2.3^{ab}	12.1±1.8^{b}	11.8±2.3^{ab}	10.5±2.1^{a}	11.1±2.0^{a}
Small scale	1st	9.8±1.9^{a}	13.5±2.5^{a}	13.4±1.1^{a}	12.9±2.5^{a}	13.0±2.2^{a}	12.6±2.1^{a}
	2nd	8.0±1.9^{a}	10.3±.8^{a}	10.9±2.7^{a}	10.2±1.2^{a}	10.3±3.2^{a}	10.0±2.2^{a}
	3rd	5.5±1.4^{b}	6.7±2.4^{b}	6.0±1.8^{b}	6.0±2.8^{b}	5.5±2.1^{b}	6.1±2.1^{b}
	Subtotal	7.8±1.6^{a}	10.1±2.2^{a}	10.1±1.9^{ab}	9.7±1.8^{a}	9.6±2.5^{a}	9.6±2.0^{a}
Overall		8.6±1.7^{a}	10.6±2.0^{a}	11.4±1.9^{a}	11.5±2.0^{a}	9.9±2.0^{a}	10.4±1.9^{a}
	P-value	0.029	0.031	0.044	0.034	0.032	
Peri-urban							
Large scale	1st	8.3±0.5^{a}	11.0±1.2^{a}	12.3±2.3^{a}	12.3±1.3^{a}	11.3±3.0^{a}	10.8±1.7^{a}
	2nd	6.2±0.2^{a}	8.3±1.3^{b}	9.4±1.5^{a}	10.0±2.3^{a}	9.4±1.9^{a}	8.6±1.4^{a}
	3rd	4.3±0.4^{b}	5.8±1.0^{b}	6.3±1.3	6.0±1.0^{b}	6.6±1.2^{a}	5.8±1.0^{b}
	Subtotal	6.3±0.1^{a}	8.4±1.2^{b}	9.1±1.7^{b}	9.4±1.5^{a}	9.1±2.0^{a}	8.8±1.4a
Medium scale	1st	8.0±0.0^{a}	8.0±0.8^{a}	12.3±2.6^{a}	12.5±2.2^{a}	8.0±1.3^{a}	9.7±1.4^{a}
	2nd	6.5±0.7^{a}	7.0±1.1^{b}	9.6±2.9^{a}	9.8±0.8^{a}	6.0±1.2^{a}	7.5±1.3^{a}
	3rd	4.0±1.4^{b}	5.0±0.6^{b}	6.3±1.7^{b}	6.5±1.3^{b}	4.3±0.6^{b}	5.1±1.1^{b}
	Subtotal	6.5±0.8^{a}	8.3±0.8^{a}	9.3±2.4^{a}	9.4±1.4^{a}	6.9±1.0^{a}	7.9±1.3^{a}
Small scale	1st	10.0±1.5^{a}	9.1±1.3^{a}	14.0±2.0^{a}	10.8±1.8^{a}	10.6±3.3^{a}	10.4±2.0^{a}
	2nd	7.8±1.3^{a}	6.6±0.7^{a}	11.5±1.3^{b}	8.6±2.4^{a}	8.9±2.2^{a}	8.1±1.6^{a}
	3rd	5.7±1.2^{b}	4.6±0.7^{b}	8.0±2.0^{c}	5.9±1.6^{b}	5.9±1.7^{a}	5.7±1.4^{a}
	Subtotal	7.9±1.3^{a}	7.5±0.9^{a}	10.9±1.8^{ab}	8.9±1.9^{a}	8.9±2.4^{a}	8.5±1.7^{a}
Overall		6.9±0.7^{a}	8.1±1.0^{a}	9.8±2.0^{b}	9.2±1.6^{a}	8.3±1.5^{a}	8.5±1.2^{a}
	P-value	0.033	0.011	0.001	0.033	0.07	

Note: Means with the same letter of superscript in the same column did not differ significantly at ($p < 0.05$)

This finding is consistent with previous findings by Mohamed Ahmede (2004), who reported that milk yield increased with increasing lactation up to the fourth parity in Sudan. According to another report, milk production increased as parity increased until the fourth parity, and then decreased at the fifth parity (Melku Muluye *et al*., 2017). This finding is consistent with Kassu Tsegaye's (2016) findings who reported that milk yield is affected by parity, with cows in the second and third parties having higher milk yield than those in the fourth and fifth parities.

Lactation length

The results revealed that lactation length increased as genotype levels increased at different scales of the production systems. In large, medium, and small scales, the average lactation length of different genotype levels of dairy cows in urban were 283.7±43.6, 317.5±24.8, 343.5±18.1 and 345.3±17.6 days for genotype levels of 25%, 50%, 75%, and >75%, respectively, with an overall lactation length of 323.0±46.7 days. The average lactation length of different genotype levels of dairy cows in peri-urban were different in large, medium, and small scales of 293.0±52.1, 327.7±42.6, 324.8±35.0 and 330.6±40.2 for genotype levels of 25%, 50%, 75%, and >75%, respectively, with an overall lactation length of 319.0±45.6 days (Table 4).

Table 4. Lactation length (in days) of crossbred dairy cows in the study areas (Mean±SD)

Production system	Production scale	Genotype levels				Overall
		25% (N=45)	50% (N=45)	75% (N=45)	>75% (N=45)	
Urban	Large	257.1±32.4^{b}	309.0±26.3a	328.0±12.5^{b}	334.0±16.9^{b}	307.0±50.0^{a}
	Medium	281.5±33.3^{a}	321.0±29.2^{a}	350.0±17.3^{a}	348.0±12.5^{a}	325.0±40.9^{a}
	Small	312.4±51.9^{a}	322.5±10.6^{a}	347.0±24.0^{a}	351.0±22.6^{a}	333.0±49.2^{a}
	Total	283.7±43.6^{a}	317.5±24.8^{a}	343.5±18.1^{a}	345.3±17.6^{a}	323.0±46.7^{a}
	P – value	0.002	0.05	0.037	0.037	
Peri- urban	Large	286.0±54.3^{b}	314.0±40.5^{b}	326.0±35.2^{a}	318.8±35.6^{b}	311.0±47.2^{b}
	Medium	290.0±49.2^{b}	342.0±34.6^{a}	309.0±37.7^{b}	320.5±51.2^{b}	315.4±45.5^{b}
	Small	303.0±45.5^{a}	326.3±37.4^{ab}	338.5±35.5^{a}	352.5±11.3^{a}	330.1±36.9^{a}
	Total	293.0±52.1^{b}	327.7±42.6^{ab}	324.8±35.0^{a}	330.6±40.2^{b}	319.0±45.6^{b}
	P – value	0.000	0.036	0.046	0.000	

Note: Means with the same letter of superscript in the same column did not differ significantly at ($p < 0.05$), N=number of sampled dairy cows from each blood levels

This result was highly significant for genotype levels of 25% in both urban and rural areas ($p < 0.001$). The result is consistent with Keberu Belaynesh's (2000) who reported that the average lactation length of crossbred dairy cows at Agarfa Multi-purpose Training Center was 330.72.0 days. It was also consistent with the findings of Mulugeta Ayalew and Belayneh Asefa (2013), who reported that the lactation period for crossbred dairy cows in North Showa was 333.9 days. However, this result was longer than Zewudie Wondatir's (2010) who reported that the average lactation period of crossbred dairy cows in Debre Birhan was 300.0±21.2 days.

CONCLUSION

The findings of this study revealed that crossbred dairy cows have a higher age at first service, age at first calving, and calving interval. The average daily milk yield of crossbred dairy cows increased with genotype level, and it varied between large, medium, and small-scale dairy farms. At all scales and systems of dairy production, the average daily milk yield increased from parity one to parity four, then decreased to

parity five. Lactation length was longer on small-scale urban and peri-urban dairy farms than on medium- and large-scale farms. However, the expected milk yield did not correspond to the crossbred cows' milking potential. As a result, it is recommended that crossbred dairy cow reproductive management be improved in order to reduce the age at first service, age at first calving, and calving interval. Crossbred dairy cows' milk production potential also falls short of their milking capacity, necessitating an improvement in farm management practices.

CONFLICT OF INTEREST

The authors declare no competing interests.

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REFERENCES

Adebabay Kebede (2009.) Characterization of milk production systems, marketing and on-farm evaluation of the effect of feed supplementation on milk yield and milk composition of cows at Bure district, Ethiopia. MSc Thesis. Bahir Dar University, Ethiopia.

Amare Berhe, Kefena Effa, Yesihak Yusuf and Million Tadesse (2019). Reproductive and productive performance of holstein friesian and crossbreed dairy cattle at large, medium and small-scale dairy farms in Ethiopia. *International Journal of Advanced Research in Biological Science*s **6**(6): 15–29.

Arsham, H. (2002). Questionnaire design and surveys sampling, SySurvey: The online survey tool.

Aynalem Haile, Workneh Ayalew, Noah Kebede, Tadelle Dessie and Azage Tegegne (2011). Breeding strategy to improve Ethiopian Boran cattle for meat and milk production. IPMS (Improving Productivity and Market Success) of Ethiopian Farmers Project Working Paper 26. Nairobi, Kenya, ILRI.

Bayrau Girmay and Berihu Gebrekidan (2014). Assessment of productive and reproductive parameters of crossbred cows in four selected weredas of Tigray, Ethiopia College of Veterinary Medicine, Mekelle University, Ethiopia. *International Journal of Livestock Research* **4**(7): 25–31.

Belay Duguma (2020). Productive and reproductive performance of crossbred and indigenous dairy cows at smallholdings in selected towns of Jimma Zone, Ethiopia. *Animal Production Science* **61**(1): 92–100.

Belay Duguma, Yisehak Kechero and Janssens, G.P.J. (2012). Productive and reproductive performance of Zebu X Holstein-Friesian Crossbred Dairy Cows in Jimma Town, Oromia, Ethiopia. *Global Veterinarian* **8**(1): 67–72.

Berry, D.P., Wall, E and Pryce, J.E. (2014). Genetics and genomics of reproductive performance in dairy and beef cattle. *Anima* **8**(1):105–21. DOI: 10.1017/S1751731114000743.

CSA (Central Statistical Agency). (2021). Agricultural sample survey 2020/21. Volume II report on livestock and livestock characteristics (private peasant holdings). Central Statistical Agency (CSA), Addis Ababa, Ethiopia.

Dobson, H., Smith, R.F., Royal, M.D., Knight, C.h. and Sheldon, I.M. (2007). The high producing dairy cow and its reproductive performance. *Reproduction in Domestic Animals* **42**(2): 17–23. doi:10.1111/j.1439-0531.2007.00906.x

Getahun Kefyale, Tadesse Million, Hundie Direba and Tadesse Yosef (2020). Productive performance of crossbred cattle. *Ethiopian Journal of Agricultural Sciences* **30**(2): 55–65.

Haftu Kebede (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.

Hunduma Dinka (2012). Reproductive performance of crossbred dairy cows under smallholder condition in Ethiopia. *International Journal of Livestock Production* **3**(3): 25–28.

Kassu Tsegaye (2016). Assessment of milk production and marketing systems, and evaluation of the productive performances of crossbred dairy cows in Bona Zuria district of Sidama Zone, Southern Ethiopia. MSc Thesis. Hawassa University.

Keberu Belaynesh (2000). Milk production and lactation performance of crossbred (Fresian × Arsi) Cattle at Agarfa multipurpose training center, Bale, Ethiopia. Alemaya University of Agriculture, Ethiopia.

Melku Muluye, Kefyalew Alemayehu and Solomon Gizaw (2017). Milk Production performances of local and crossbred dairy cows in West Gojam Zone, Amhara Region, Ethiopia. *Journal of Applied Animal Science* **10**(1): 35–46.

Million Tadesse, Thiengtham, J., Pinyopummin, A and Prasanpanich, S. (2010). Productive and reproductive performance of Holstein Friesian dairy cows in Ethiopia. *Livestock Research for Rural Development* **22**(2): 21.

Mohamed Ahmede (2004). Studies of some performance traits of Butana cattle in Atbara live-stock research station. MSc thesis University of Khartoum, Sudan.

Mulugeta Ayalew and Belayeneh Asefa (2013). Reproductive and lactation performances of dairy cows in Chacha town and nearby selected peasant associations, North Shoa Zone, Amhara Region, Ethiopia. *World Journal of Agricultural Sciences* **1**(1): 8–17.

Nibret Moges (2012). Study on reproductive performance of crossbred dairy cows under small holder conditions in and around Gondar, North Western Ethiopia. *Journal of Reproduction and Infertility* **3**(3): 38–41.

Niraj, K., Yemane Abadi, Berihu Gebrekidan and Yohannes Hagos (2014). productive and reproductive performance of local cows under farmer's management in and around Mekelle, Ethiopia. *IOSR Journal of Agriculture and Veterinary Science* **7**(5): 21–24.

Seble Aweke and Berhanu Mekibib (2017). Major production problems of dairy cows of different farm scales located in the capital city Addis Ababa, Ethiopia. *Journal of Veterinary Science & Technology* **8**(6): 1–6.

Shiferaw Yoseph, Tenhagen BA and Merga Bekana (2005). Reproductive disorders of cross breeds dairy cows managed under different production systems in central high lands of Ethiopia. *Journal of Tropical Animal Health and Production* **37**(5): 427–441.

Tadesse Senay, Fesaha Guesh, Abebe Adugnaw, Hailu Beletech and Workalem Dejen (2014). Assessment of productive and reproductive performances of Crossbred Dairy cows in Debre tabor town. *Journal of Biology, Agriculture and Health Care* **4**(23).

Tarekegn Demeke (2020). Characterization of reproductive and productive performance of indigenous and crossbreed dairy cows in Angot District, North Wollo Zone, Ethiopia. *International Journal of Animal Science and Technology* **4**(3): 62–69.

Zewdie Wondatir (2010). Livestock production systems in relation with feed availability in the Highlands and Central Rift valley of Ethiopia. M.Sc. thesis submitted to the School of Animal and Range Sciences, School of Graduate studies Haramaya University.160 p.