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Review Article

Assessment of Reproduction and Production Performances of Smallholder Dairy Cows Under Farmer Management Conditions in East Arsi Zone, Oromia Region, Ethiopia

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Abstract

The study aimed to assess dairy cow's reproductive and productive performances in East Arsi Zone, Oromia Regional State, Ethiopia. Using a purposeful random sampling technique, 301 dairy smallholders in total were selected. Reproduction and production data were collected using semi-structured questionnaires. The GLM procedures of the SAS were used to analyze the data. The number of services per conception (NSPC) was analyzed using a decision tree. The least square means of age at first service (AFS), age at first calving (AFC), days open (DO), calving interval (CI) and NSPC for Holstein Friesian (HF) X local breeds were 21.87 ± 0.29, 31.54 ± 0.29, 91.00 ± 1.52, 13.29 ± 0.15 and 1.59 ± 0.49, respectively. The study showed a significant ($P < 0.0001$) in AFS, AFC, DO and CI between the breeds and NSPC was significant ($P < 0.001$). Age at first service and age at first calving were statistically significant ($P < 0.05$) between the production systems, whereas no significant differences in breed interaction with production systems. Moreover, the least square means of AFS, AFC, DO, CI and NSPC for local breeds were 31.02 ± 0.42, 40.64 ± 0.42, 130.17 ± 2.18, 15.57 ± 0.21 and 2.01 ± 0.47, respectively. The least square means of early daily milk yields, mid daily milk yields, late daily milk yields, daily milk yields, lactation milk yields and lactation length for HF X local breeds were 10.92 ± 0.12, 8.25 ± 0.11, 5.89 ± 0.08, 8.35 ± 0.09, 2203.61 ± 31.66 and 8.75 ± 0.09, respectively. Significant ($P < 0.0001$) differences were seen between crossbreed and local breeds in all production parameters. There was no significant ($P > 0.05$) difference between production systems and breed interaction with production systems. Similarly, the square means of early daily milk yields, mid daily milk yields, late daily milk yields, daily milk yields, lactation milk yields and lactation length for local breeds were 2.75 ± 0.18, 1.94 ± 0.16, 1.12 ± 0.12, 1.93 ± 0.14, 411.49 ± 48.95 and 7.03 ± 0.14, respectively. Crossbreed dairy cows showed better reproductive performance than local breeds in age at first service, age at first calving, days open, calving intervals and number of services per conception. Further, crossbreed dairy cows outperformed native breeds in terms of productivity. These better reproductive parameters boost herd productivity and economic profitability in crossbreed dairy cows compared to native breeds. Crossbreed can be a valuable asset for dairy farmers seeking to increase milk production while maintaining adaptability and disease resistance. Furthermore, the findings of this study suggest that producers could enhance their local breeds for improved performance via crossbreeding. However, they must protect their native breeds without diluting their bloodlines with foreign breeds.

Keywords: crossbreed, local, reproduction, production, peri-urban, rural

Introduction

Ethiopia has Africa's largest livestock population, with an estimated 66 million cattle, 38 million sheep, 46 million goats and 41 million poultry [1]. Agriculture serves as the cornerstone for people's social and economic existence. According to the FAO [2] agriculture accounts for 90% of export value, 68.2% of employment and 35% of GDP. A considerable portion of the population relies on livestock for a living and they account for around 45% of the value of agricultural products. More than 14 million families or 70 percent of the people, own livestock, including many impoverished ones. The average small herd consists of three cows, three goats or sheep and a few poultry [2]. The majority of the population lives in the highlands, where animals are kept. Despite a large cattle population and favorable environmental conditions, the nation's current livestock output remains exceptionally low. This is linked to several complex and interconnected factors, including insufficient feed and nutrition, a high disease prevalence, low genetic potential, market issues and the ineffectiveness of livestock development services such as infrastructure, credit, extension and marketing [3].

The country generates 419 million eggs, 1.1 million tons of meat and 5.6 billion liters of milk annually. Over 1 million tons of beef and over 3.8 billion liters of cow milk are produced each year, which are worth USD 5.1 billion and USD 2.5 billion, respectively. However, data on overall production levels can vary significantly depending on the source. The value of organic fertilizers (68 million tons) and animal-derived draft power (617 million days per year) is not reflected in the extremely changeable production statistics [2]. Ethiopia's economy is heavily reliant on agriculture, particularly in rural and semi-urban areas and cattle play a huge role in this agricultural activity. Livestock farming, particularly dairy production, is a prominent industry in both urban and rural Ethiopia, serving primarily for home consumption in rural areas and as a source of revenue [4].

Milk demand has risen considerably in recent decades, particularly in developing countries, while supply has maintained pace [5]. Developed countries consume 200 kilograms or more of milk per person per year, whereas undeveloped countries consume only 40 kg on average [5]. However, the nation consumes 43.3 kg of milk per person per year, which is significantly lower than the global average [2]. This is related to cow's low productive and reproductive performance, which includes daily milk yields, lactation length, lactation milk yields, age at first calving, calving interval, days open and the number of services per conception. Several factors, including low genetic makeup, feed costs, low feed quantity and quality, disease and a lack of extension services, contribute to crossbreed dairy cow's poor performance [6].

Several studies have been conducted in various parts of the country to assess the performance of crossbreed dairy cows with different exotic blood levels in relatively controlled conditions in the country's urban and peri-urban dairy farming areas [7]. Similarly, efforts to build breeding programs for numerous livestock species in the country were unsuccessful due to a lack of commitment and interaction with diverse stakeholders. As reproductive efficiency is the most important element determining dairy cow performance, it is an outstanding and crucial feature in dairy cattle production [8]. To establish successful breed development techniques, the success of crossbreeding programs in particular and dairy production in general must be routinely evaluated by assessing productive performance under the current management system [9]. However, information on the productive and reproductive performance of crossbreed dairy cows under smallholder dairy production systems is limited and not documented, mainly in peri-urban and rural smallholders in the East Arsi zone of Lemunabilbilo, Tiyo and Digelunatijo districts. Following that, the sector must be evaluated in a systematic and organized manner. As a result, understanding dairy cattle's reproductive and productive performance is critical to Ethiopia's long-term dairy production success. Therefore, the study's objective was to assess the productive and reproductive performance of dairy cattle in the study locations.

Methods and Materials

Description of the study areas and site selection

The study was carried out in the East Arsi Zone of the Oromia Regional State, which is located at 7°08′58′′ to 8°48′00″N latitude and 34°41′55″ to 40°43′56″E longitude. Assela serves as the zone and Tiyo district administrative center. Assela is about 175 kilometers southeast of Addis Ababa and has an elevation of 2430 meters above sea level. Mount Chilalo is the highest point in the Arsi Zone. The zone covers an area of 19,825.22 km2 and is divided into 25 districts. The mean annual rainfall ranges from 633.7 mm to 1020 mm, while the average yearly temperature ranges from 10°C to 25°C. Three districts (Lemunabilbilo Tiyo and Digelunatijo) were purposely chosen from 25 districts.

The Lemunabilbilo district is located at 7°43′18″ latitude and 39°17′51″ longitude about 223 kilometers southeast of Addis Ababa. Bokeji serves as the district administrator. The district has 81,400 hectares (ha) of land total, of which 70,154 are used for crop cultivation, 6,746 for grazing, 3,839 for forest, 262 for bush and shrub cover, 99 for barren land and 300 ha for other uses. The district climatic conditions are varied, featuring agroecologies such as highlands (80%), midlands (17%) and lowlands (3%), with elevations ranging from 2500 to 3560 meters above sea level. The district has an annual rainfall of 1000-1200 mm and a temperature of 13°C. The district has two main rainy seasons: a long one from June to August and a short one from mid-March to April.

The Tiyo district is located at 7°50′N latitude and 39°10′E longitude at 167 kilometers southeast of Addis Ababa. Of the 65,000 ha of land in Tiyo, 25,060 are used for crop cultivation, 9,697 for grazing, 3,959 for forest, 9,479 for bush and shrub, 10,828 barren land and 5,977 ha for other uses. The district climate conditions are varied, featuring agroecologies of midlands (52%), highlands (37%) and lowlands (11%) with elevations ranging from 2300 to 3200 meters above sea level. Tiyo experiences 1300 mm to 1350 mm of annual rainfall, with an average temperature of 18 to 25 °C during the dry season and 5 to 10°C during the wet season. The district has two main rainy seasons: a long one from June to August and a short one from February to April. Its climate and soil provide extremely fruitful environmental conditions.

The Digelunatijo district is located at 7°46′ latitude and 39°15′E longitude at 192 kilometers southeast of Addis Ababa. Segure serves as the district administrative. The district comprises 92,700 ha of land, of which 43,873 are cultivated for crops, 15,054 for grazing, 11,122 for forests and 22,651 ha are used for other uses. The district agroecologies are midlands (22%) and highlands (78%), with elevations ranging from 2500 to 3560 meters above sea level. The district has an annual rainfall of 1200 mm and a temperature of 10-15°C. The region has two distinct rainy seasons: a long one from June to September and a short one from mid-March to April.

Study design and study population

A multi-stage purposeful sampling strategy was used. Livestock and fishery office experts of the district were briefed on the study's objectives. First potential districts were purposively selected. Second, based on the information from the districts' livestock and agriculture development agencies, peri-urban and rural Kebeles in each district were purposefully selected based on dairy animal availability and road accessibility. Finally, dairy producers were selected at purposeful random from each production system and informed about the study's aims. The study population was smallholder dairy owners who owned dairy cows in the study area.

Sampling procedures and sample size determination

A purposeful sampling technique was employed. The sample size was determined based on the formula given by [10] for survey studies:

$N = 0.25/SE^2 = 0.25/0.05^2$, Where: SE = Standard error, N = required sample size.

At 5% standard error, 301 households were chosen (Lemunabilbilo = 100, Tiyo = 101 and Digelunatijo = 100).

Data collection methods and data analysis

The data were collected using semi-structured questionnaires from March 2022 to November 2023. The farmers were interviewed in person about the reproduction performance of dairy cows (AFS, AFC, DO, CI and NSPC) and production performance (early daily milk yields, mid daily milk yields, late daily milk yields, daily milk yields, lactation milk yields and lactation length). The data were entered and organized in the Excel spreadsheet and then subjected to statistical analysis using SAS version 9.0 software. GLM procedures of the SAS were used to estimate quantitative data. Descriptive statistics such as least square means and standard error were used. A mean comparison was performed using an LSD comparison. The number of services per conception was analyzed using a decision tree using SPSS software version 27.

Model

Where: $Yijk = \mu + Bi + Cj + Bi * Cj + eijk$

Yijk is k^th response parameters from i^th breeds managed under the j^th production system

μ is the overall mean

Bi is i^th breed (i=2, crossbreed and local breed)

Cj is j^th production systems (j=2, rural and peri-urban)

Bi*Cj is the interaction between production systems and breeds

eijk is the error term

Results and Discussion

Reproduction performances of dairy cows

Age at first service

Tables 1 and 2 highlight dairy cow's reproductive performance. The age at first service (AFS) differed considerably between Holstein Friesian (HF) X local breeds and local breed ($P < 0.0001$) and production systems ($P < 0.05$). However, the interaction between breeds and production systems was not statistically significant ($P > 0.05$). Crossbreed dairy cows attained AFS earlier than local cows Table 1. This could be attributed to the genetic superiority of HF X local breed dairy cows compared to local cows. Crossbreed dairy cows had the least square means of AFS 21.87 ± 0.29 months. These findings are shorter than 24.30 ± 8.01 months in Jimma town [11], 32.05 ± 0.57 months at Agarfa ATVET college [12], 30.3 ± 4.4 months in Sidama Zone, Southern Ethiopia [13], 849.58 ± 9.30 days in Ethiopia [14] and 22.29 ± 6.28 months in North Shoa Zone [15]. Further, this result is shorter than the average AFS of 950 ± 26 days for HF X Arsi breeds [16]. Age at first service plays a crucial role in the profitability and sustainability of dairy businesses. Animals that attained AFS earlier had longer lactation length, resulting in higher milk production over their lifetime. Similarly, it reduces feed costs by starting milk production soon, reducing their time as non-productive animals. Dessalegn et al. [17] found that crossbreed dairy cows in Bishoftu and Akaki had an average AFS of 18.7 ± 3.7 and 18.7 ± 3.5 months, respectively, which was shorter than the current results.

The study found significant ($P < 0.05$) differences in AFS between rural and peri-urban production systems. The least squares means of AFS were 25.85 ± 0.31 and 27.03 ± 0.41 months in rural and per-urban production systems, respectively. The animals in rural production systems achieved AFS more quickly than peri-urban production systems, attributed to the abundance of grazing land in rural areas. Admasu., *et al*. [15] found that crossbreed dairy cows had AFS of 24.19 ± 7.17 and 20.28 ± 4.4 months in peri-urban and urban production systems in the North Shoa Zone, respectively, which was shorter than the current results. Furthermore, the obtained least square means in rural and peri-urban production systems is greater than the average AFS for crossbreed dairy cows 21.6 ± 4.9 months in urban Assela, 21.9 ± 6.1 months in urban and 21.8 ± 5.4 months peri-urban Holetta, and 18.8 ± 2.2 months in urban and 19.1 ± 5.3 months in peri-urban Bishoftu [18]. In contrast, Abebe and Demissie [18] reported longer AFS in peri-urban Assela (29.3 ± 10.9 months), whereas 25.4 ± 7.1 and 25.9 ± 7.2 months, respectively, in urban and peri-urban Sululta were comparable to the results obtained from rural production systems. Moreover, the least squares mean AFS obtained in this study is shorter than the average AFS of 46.35 ± 0.062, 45.84 ± 0.088, and 38.1 ± .098 months in rural, per-urban, and urban production systems respectively, in West Shoa Zone, Oromia Regional State, Ethiopia for local cows [19]. Chala., *et al*. [20] found that the average AFS for local cows was 40.5 ± 0.89 and 42 ± 1.67 months in the lowland and midland regions of Bako Tibe district, West Showa Oromia Regional State, Ethiopia, respectively, which was longer than the current results.

This study's least squares means of AFS for local cows is lower than 48.42 ± 0.05 months for local cows in the Horro district [21] and 44.1 ± 5.9 months for local cows in Sidama Zone, Southern Ethiopia [13]. Furthermore, the obtained least squares means of AFS for native cows is lower than the average AFS of 3.76+0.07 years in the Bule Hora districts and 3.39+0.42 years in the Dugda Dawa districts, but comparable to 2.45+1.16 years in Karcha districts for indigenous cows in West Guji Zone [22]. Animals kept in rural production systems attained AFS before those raised in peri-urban production systems. The diversity in AFS could be attributed to differences in feed supply, the influence of breeds, and management across multiple locations. Due to the cow's prolonged, non-lactating, unproductive phase of many months, a considerable delay in achieving sexual maturity may result in a significant economic loss [23]. Interestingly, early animal maturity can lead to lower rearing costs as it saves money on feed, labor, and construction.

Age at first calving

Age at first calving (AFC) is one of the most prominent measures used to evaluate the effectiveness of replacement rearing programs in dairy herds. Optimal AFC is crucial for reducing breeding expenses and prolonging the herd life of dairy cattle. The study found that AFC was significant ($P < 0.0001$) between breeds and production systems ($P < 0.05$), but not significant between breed interaction with production systems ($P > 0.05$). Local cows had longer AFCs than crossbreed cows. The least squares means of AFC for crossbreed dairy cows was 31.54b ± 0.29 months. These results are shorter than the average AFC of 3.05 ± 0.65 years in Jimma town [11], 41.16 ± 0.56 months at Agarfa ATVET College [12], 39.3 ± 3.2 months in Sidama Zone, Southern Ethiopia [13] and 1125.44 ± 9.28 days in Ethiopia [14] for crossbreed cows. Furthermore, the current study's least squares means of AFC is shorter than the average AFC of 34.8 ± 4 months in Assela [24], 36.4 ± 1.7, 32.4 months in Mekele [4], 32.4 months in Gonder [25] and 1314 ± 67days in Assela [16] for crossbreed dairy cows. On the other hand, the present findings are longer than the average AFC 27.0 ± 3.7 and 26.9 ± 5.4 months in Bishoftu and Akaki for crossbreed dairy cows [17] but it is comparable to 31.9 ± 0.22 months in Zeway [26], 31.58 ± 6.5 months in North Shoa Zone [15] and 30.50 months in Nepal [27]. Animals with an ideal AFC are more likely to have successful rebreeding rates, resulting in shorter calving intervals and higher milk production. Moreover, animals calving at an earlier age have a shorter pre-calving period which can reduce production costs and rearing.

For the local cows, the least squares means of AFC (Table 1) obtained in this study is shorter than the average AFC of 51.9 ± 5.9 months in Sidama Zone, Southern Ethiopia [13] and 4.12+0.52 years in West Guji Zone, Oromia Region [22] for local cows. Furthermore, the acquired AFC in this study is shorter than the average AFC of 58.08 ± 0.07 months for local cows in the Horro district [21] and 48.9 ± 0.26 months for native heifers in Dawro Zone, Southern Ethiopia [28]. However, the least squares means of AFC obtained in this study is longer than the average AFC of 36.06 ± 1.22 and 38.33 ± 1.85 months for local cows in urban and rural production systems, respectively in and around Assosa town [29]. However, shorter than the average AFC of 54.22 ± 0.068, 53.34 ± .096, and 49.50 ± .108 months in rural, per-urban, and urban production systems, respectively, for local cows in the West Shoa Zone, Oromia [19]. Furthermore, the least square means of AFC obtained in the current study is shorter than the average AFC of 49.5 ± 0.09 and 51.5 ± 0.69 months for local cows in the midland and lowland, respectively, in Bako Tibe district, West Showa, Oromia Regional State [20].

Animals raised in rural production systems attained AFC earlier than those raised in peri-urban production systems table 1. The study revealed that production systems did not affect AFC which is consistent with the study conducted in the central zone of Tigray, Northern Ethiopia [30]. The least squares means of AFC obtained in rural and peri-urban production systems in this study is longer than the findings of Abebe and Demissie [18], who reported that the average AFC was 34.4, 34.9 months in urban and per-urban Sululta, respectively but shorter than 38.3 months in peri-urban Assela. Furthermore, the least squares means of AFC in this study is longer than the average AFC of 33.6 ± 7.3 and 29.4 ± 4.7 months of AFC for crossbreed dairy cows in peri-urban and urban production systems, respectively in the North Shoa Zone [15]. Moreover, this study's results are shorter than the average AFC of 34.8 ± 4 months in Assela [24], but shorter than 37.5 ± 0.6 months for crossbreed dairy cows near Wolaita Sodo town [31]. Abebe and Demissie [18] found that crossbreed dairy cows had shorter average AFC in urban Assela (30.6 ± 4.9 months), urban and peri-urban Bishoftu (27.8 ± 2.2 and 28.1 ± 5.3 months), and urban and peri-urban Holetta (30.5 ± 6.2 and 30.5 ± 5.4 months). As AFS, age at first calving plays a crucial role in the profitability and sustainability of dairy businesses. The higher AFC and variance observed in several studies could be attributable to husbandry techniques, genetic potential and environmental factors that influence cow growth. These may reduce fertility and conception, retard the rate of growth, and delay puberty. To reduce AFC, it is crucial to improve animal housing, management, disease control and nutrition, and the nutritional profiles of feeds available. This is especially critical during harsh weather conditions.

Days open

The days open (DO) are critical to the whole productive lives of dairy animals. The optimal service period allows the animal to recuperate from the stress of calving while also restoring the reproductive organs to normal. The least square mean of DO for crossbreed dairy cows was 91.00 ± 1.52. The study found significant differences (P < 0.0001) in DO between the breeds. In contrast, there was no significant (P > 0.05) variation in DO between production systems or breed interaction with production systems. The findings revealed that crossbreed dairy cows had shorter DO than native cows Table 1. This study's least square means DO is nearly equivalent to the upper recommended range of 75-90 days for a well-managed dairy farm [32]. This implies that the animals are living in optimal settings. Days open is an important indicator in dairy cattle management since it indicates the time between calving and successful rebreeding. This parameter is used to evaluate reproductive efficiency and pinpoint areas for improvement in a herd. This finding is comparable to the average DO of 81.23 and 97.50 days for Jersey and Holstein crossbreed dairy cows, respectively in Nepal [27]. This study's least squares means of DO for crossbreed dairy cows is shorter than the average DO of 5.19 ± 1.72 months in Jimma town [11], 200.13 ± 25.55 days at Agarfa ATVET College [12], 103.02 ± 1.70 days in Ethiopia [14] and 209 ± 6 days in Assela [16] for crossbreed dairy cows. On the other hand, the current study's least squares means of DO for local cows is longer than the average DO of 91.5+0.38 days for local cows in the West Guji Zone [22]. However, the least squares means of DO recorded in this study is shorter than the average DO of 148 ± 1.72 days in Holetta [33] and 160.5 ± 0.08 days in Bako Tibe districts west of Showa Oromia regional state, Ethiopia [20].

The results revealed no significant difference in DO between the production systems (P > 0.05). This study's least squares means of DO values is shorter than the average DO of 127.5 ± 36.7 and 168.0 ± 78.1 days for urban and per-urban Assela, 128.3 ± 42.4 days for per-urban Bishoftu, and 123.2 ± 39.3 and 136.6 ± 64.2 days for urban and per-urban Sululta for crossbreed dairy cows [18]. However, the study's finding is longer than that of 108.6 ± 25.5 days for peri-urban Holetta, and 101.5 ± 26.4 days for urban Holetta for crossbreed dairy cows [18]. The least squares means of DO for local cows obtained in this study is shorter than that of 160 ± 0.08 and 161 ± 0.15 days for local cows in midland and lowland, respectively, in Bako Tibe district, West Showa Oromia Regional State [20]. Furthermore, the obtained least square means of DO is lower than that of Megersa [19], who reported that for local cows in West Shoa Zone, Oromia Regional State, their respective observations were 235.8 ± 23.00 days in rural, while longer than 207.5 ± 21.00, and 207.3 ± 15 days, per-urban, and urban production systems, respectively. A prolonged dry period is always uneconomical for the dairy industry, whereas a short dry period can have a negative impact on future lactation. Poor heat detection, insufficient and low-quality feed supply, breed contribution, and environmental variables could all contribute to the extended dry period. Moreover, the variation in the number of days open could be linked to silent heat, which is difficult to detect, management changes, and feed offered to the animals.

Calving interval

The calving interval determines the dairy cow's production life, which can influence the profitability and sustainability of the dairy industry. The study's least square means of calving interval (CI) for crossbreed dairy cows was 13.29 ± 0.15 months. The study found a significant (P < 0.0001) variation in CI between breeds. However, there is no significant difference (P > 0.05) between production systems and breed interactions with production systems. The native cows had a longer (15.57 ± 0.21 months) CI than crossbreed cows (Table 1). This could be attributed to poor fertility in local breeds compared to HF crossbreed dairy cows.

This result is longer than the average CI of 364.23 and 380.50 days for Jersey and Holstein crosses with native breeds, respectively in Nepal [27]. This could be due to variances in management and environmental factors. On the other hand, this study's CI for crossbreed dairy cows is shorter than the average CI of 21.36 ± 3.84 months in Jimma town [11], 475.92 ± 3.44 days at Agarfa ATVET College [12], 17.1 ± 4.5 months in the Sidama Zone of Southern Ethiopia [13] and 15.10 ± 2.60 months in the North Shoa Zone [15] for crossbreed dairy cows. Further, this result is shorter than the average CI of 488 ± 6 days for HF X Arsi breeds in Assela [16]. The least square means obtained in this study are comparable to the average of CI 13.0 ± 2.1 and 13.8 ± 1.9 months of CI for crossbreed dairy cows in Bishoftu and Akaki, respectively [17]. However, the current result is shorter than the average CI of 374.72 ± 2.12 days for crossbreed dairy cows in Ethiopia [14]. Moreover, shorter than 23.6 ± 4.4 months in Sidama Zone, Southern Ethiopia [13], 22.19 months in the Abuna Gindeberet district of West Shewa Zone of Oromia Regional State [34], 16.0 ± 0.141 months in Dawro Zone, Southern Ethiopia [29] and 16.71+ 0.53 months in West Guji Zone, Oromia Regional State [22] for local cows. Calving interval is a vital reproductive measure in dairy cattle farming. This parameter influences herd productivity and overall profitability.

The study found no significant difference ($P > 0.05$) in CI between rural and peri-urban production systems, which is consistent with Gebrekidan et al. [30] who reported a non-significant difference in CI for crossbreed dairy cows between urban and peri-urban dairy production systems in the central zone of Tigray, Northern Ethiopia. This study's CI least square means correspond to the average CI of 15.3 ± 2.51 and 14.90 ± 2.60 months for crossbreed dairy cows in peri-urban and urban production systems in the North Shoa Zone [15]. The CI obtained from the rural and per-urban production systems are longer than 13.7 ± 1.3 months in urban Assela, 13.9 ± 2.0 months in peri-urban Sululta, 12.9 ± 0.8 and 13.6 ± 4.4 months in urban and peri-urban Bishoftu, 12.7 ± 1.1 and 13.0 ± 1.0 months in urban and peri-urban Holetta and 13.3 ± 1.1 months in urban Sululta [18]. Furthermore, the average CI of 13.00 ± 0.39 and 13.50 ± 0.70 months in urban and rural production systems were reported in and around Assosa town [29], which was shorter than the current findings. However, the results reported in this study are shorter than 20 ± 0.10 and 28 ± 0.07 months for indigenous dairy cows in the Bako Tibe district, West Showa Oromia Regional State, Ethiopia [20]. Moreover, a longer CI of 748.25 ± 0.05, 743.50 ± 0.04, and 724.53 ± 0.03 days for local dairy cows in per-urban, urban, and rural production systems was reported in the West Shoa Zone of Oromia Regional State, Ethiopia [19] compared to the current finding. Dairy cattle should reproduce at reasonable intervals to ensure profitable milk production and maximum reproductive efficiency. However, poor diet, improper management practices, breed type, long days without successful mating, ineffective breeding systems and diseases can all contribute to inconsistent CI. The differences in average CI between studies conducted in the country could be due to varying management approaches, resulting in different responses within and between breeds. Implementing estrus synchronization and assisted reproductive technologies can help optimize calving intervals.(Table 1,2)

Variables		Nº	AFS (month)	AFC (month)	DO (day)	CI (month)
Overall mean		459	24.89 ± 0.31	34.55 ± 0.31	104.41 ± 1.49	14.12 ± 0.13
Breed	Crossbreed	301	21.87^{b} ± 0.29	31.54^{b} ± 0.29	91.00^{b} ± 1.52	13.29^{b} ± 0.15
	Local breed	158	31.02^{a} ± 0.42	40.64^{a} ± 0.42	130.17^{a} ± 2.18	15.57^{a} ± 0.21
Production	Rural	279	25.85^{b} ± 0.31	35.52^{b} ± 031	110.24^{a} ± 1.61	14.63^{a} ± 0.16
	Peri-urban	180	27.03^{a} ± 0.41	36.65^{a} ± 0.41	110.93^{a} ± 2.12	14.23^{a} ± 0.20

Table 1: Least square means ± SE of reproduction performances of dairy cows.

Within columns and main effects means lacking common superscript differ ($P < 0.05$). AFS: Age at First Service; AFC: Age at First Calving; DO: Days Open; CI: Calving Interval.

Variables	Nº	AFS (month)	AFC (month)	DO (day)	CI (month)
Crossbreed*Rural	175	21.57^{a} ± 0.38	31.29^{a} ± 0.38	91.25^{a} ± 1.97	13.25^{a} ± 0.19
Crossbreed*peri-urban	126	22.17^{a} ± 0.45	31.79^{a} ± 0.45	90.75^{a} ± 2.32	13.33^{a} ± 0.22
Local breed*Rural	104	30.14^{a} ± 0.49	39.76^{a} ± 0.49	129.23^{a} ± 2.55	16.01^{a} ± 0.25
Local breed*peri-urban	54	31.89^{a} ± 0.68	41.52^{a} ± 0.69	131.11^{a} ± 3.54	15.13^{a} ± 0.34

Table 2: The least square means ± SE of reproduction performances of dairy cows (Breed*Production System).

The interaction effects do not differ ($P > 0.05$). AFS: Age at First Service; AFC: Age at First Calving; DO: Days Open; CI: Calving Interval.

Number of service per conception

The conception rate is an important part of dairy cow production and reproduction. The least square means of NSPC for crossbreed and native breeds were 1.59 ± 0.49 and 2.01 ± 0.47, respectively. Crossbreed dairy cows required fewer services per conception than native cows. This is due to the animal's genetic potential and high fertility for crossbreed than local cows. Breed significantly affects NSPC (P < 0.0001), while there was no significant difference (P > 0.05) between the production systems. The study discovered that the least square means of NSPC for crossbreed in peri-urban and rural production systems were 1.56 ± 0.50 and 1.61 ± 0.49, respectively. The least squared means of NSPC for local breeds in peri-urban and rural production systems were 1.93 ± 0.47 and 2.06 ± 0.46, respectively. This indicated that breed improvement was more important than production systems.

This result is comparable to the average NSPC of 1.74 and 1.50 times for Jersey and Holstein crossbreeds with local breeds in Nepal, respectively [27]. The study's findings for rural and peri-urban production systems are comparable to the average NSPC of 1.56 ± 0.57 in Jimma town [11] and 1.7 ± 0.59 cows in Ethiopia [14] for crossbreed dairy cows. Furthermore, the NSPC obtained in this study from the rural and peri-urban production systems are comparable with 1.65 ± 0.5 in urban Bishoftu, 1.5 ± 0.6 and 1.6 ± 0.61 in urban and per-urban Holetta, and 1.6 ± 0.5 in per-urban Sululta, but less than 1.85 ± 0.61 in per-urban Bishoftu for crossbreed dairy cows [20]. However, this result is higher than the average NSPC of 1.35 ± 0.03 at Agarfa ATVET College for crossbreed dairy cows [12]. Moreover, the mean NSPC obtained in this study is higher than 1.4 ± 0.6 and 1.3 ± 0.4 in urban and per-urban Assela and 1.3 ± 0.3 in urban Sululta, respectively [18]. On the other hand, the study's mean NSPC from rural and peri-urban production systems is lower than the average NSPC of 1.8 for crossbreeds in the Sidama Zone in southern Ethiopia [13], 1.81 NSPC for crossbreed dairy cows in the central highlands of Ethiopia [33], 1.77 ± 0.95 of NSPC for crossbreed dairy cows in the North Shoa Zone [15] and 1.82 ± 0.032 for HF X Arsi crossbreed dairy cows in Assela [16]. A lower NSPC indicates higher fertility and better reproductive management practices.

The least square means NSPC achieved in this study for local cows from rural and peri-urban production systems exceeds the 1.6 reported in the Arsi Zone [35]. Additionally, it is greater than 1.66 ± 0.14 in midland, but equivalent to 1.9 ± 0.09 services in the lowland in Bako Tibe region, West Showa Oromia Regional State, Ethiopia [20] and 2.1 in and around Horro-Guduru Livestock Production and Research Center, Ethiopia [36]. On the other hand, the study's least square means NSPC is lower than 2.2 in and around Mekele [37] and 2.4 in Sidama Zone, Southern Ethiopia [13]. Furthermore, higher NSPC (3.7 ± 0.07, 3.0 ± 0.10, and 3.0 ± 0.11 times) were reported for local dairy cows in rural, per-urban, and urban production systems than the current results, respectively, in West Shoa Zone, Oromia Regional State, Ethiopia [19]. The variation in reproduction performance among authors can be attributed to differences in how animals are managed and what they are fed, both within and across different breeds and situations. Factors such as poor nutrition, genetic differences, inadequate heat expression and detection, early insemination, and other related management approaches could all contribute to differences in the number of services per conception.

Production performances of dairy cow

Daily milk yield

The amount of milk a herd produces is crucial for the profitability of dairy operations. A cow that produces a high amount of milk is cost-effective to the owner compared to a low-producing one. Milk production plays a vital role in determining the true economic value of cattle herds. Tables 3 and 4 summarize the production performances of dairy cattle. The study found a significant difference (P < 0.0001) in early daily milk, mid daily milk, late daily milk and daily milk yields between the crossbreed and local breeds. This could be explained that HF X local breeds have a higher genetic potential for milk production and feed conversion efficiency to production than native breeds However, the study found no significant (P > 0.05) difference between production systems and breed interaction with production systems for early daily, mid daily, late daily and daily milk yields (Table 3).

The least squares mean of early daily milk yields per day per cow for crossbreed dairy cows was 10.92 ± 0.12 l. The average early daily milk yields of 8.9 ± 3.5 and 8.4 ± 3.7 l per day per cow cows from medium and small farm sizes were reported, respectively for crossbreed dairy cows in the central zone of Tigray, Northern Ethiopia [30], which was lower than the current finding. The study's least square mean is comparable with 11.0 ± 4.8 l per day per cow from a large farm size [30]. In this study, mid daily milk yields are

Variables		Nº	DEY (liter)	DmiY (liter)	DLY (liter)	DMY (liter)	LMY (liter)	LL (month)
Overall mean		442	8.32 ± 0.12	6.22 ± 0.16	4.35 ± 0.12	6.30 ± 0.16	1633.63 ± 47.40	8.23 ± 0.08
Breed	Crossbreed	301	10.92^a ± 0.12	8.25^a ± 0.11	5.89^a ± 0.08	8.35^a ± 0.09	2203.61^a ± 31.66	8.75^a ± 0.09
	Locaal breed	141	2.75^b ± 0.18	1.94^b ± 0.16	1.12^b ± 0.12	1.93^b ± 0.14	411.49^b ± 48.95	7.03^b ± 0.14
Production systems	Rural	271	6.88^a ± 0.13	5.04^a ± 0.11	3.42^a ± 0.08	5.11^a ± 0.10	1315.26^a ± 34.41	8.03^a ± 0.10
	Peri-urban	171	6.80^a ± 0.17	5.15^a ± 016	3.57^a ± 0.12	5.18^a ± 0.13	1299.84^a ± 47.06	7.75^a ± 0.14

Table 3: Mean ± SE production performances of dairy cows.

Within columns and main effects means lacking common superscript differ ($P < 0.05$). DEY: Daily Early Yield; DmiY: Daily Mid Yield; DLY: Daily Late Yield; DMY: Daily Milk Yield; LMY: Lactation Milk Yield; LL: Lactation Length

higher than 7.2 ± 2.8 and 6.7 ± 2.4 l per day per cow for medium and small farm sizes, respectively, but equivalent to 9.0 ± 3.1 l per day per cow for big farm sizes [30]. Furthermore, lower late daily milk yields for medium and small farm sizes (4.0 ± 1.4 and 4.1 ± 2.1 l) were reported, respectively [30] compared to current results, but equivalent to 5.8 ± 2.4 l for large-scale farms. Early daily milk yields (2.75 ± 0.18) from local cows are smaller than those reported by Gebrekidan et al. [30], who found early daily milk yields of 3.5 ± 1.3 and 3.2 ± 1.8 l per day per cow for local cow from large and medium farm sizes, respectively, but comparable to 2.5 ± 1.2 l per day per cow for small farm sizes in Tigray's central zone. Similarly, the least square means mid daily milk yields obtained in this study from local cows are smaller than the average mid daily milk yields of 4.16 ± 2.3 l per day per cow for big farm sizes [30]. On the other hand, this study's least square means mid daily milk yields are close to Gebrekidan et al. [30], who reported average mid daily milk of 1.9 ± 0.7 and 2.4 ± 1.1 l per day per cow for medium and small farm sizes, respectively. In late daily milk yields, a large farm size produced 2.0 ± 1.0 l per cow per day, which was higher than the current findings. In contrast, the average late daily milk yield in this study is comparable to 1.3 ± 0.58 and 1.0 ± 0.4 l per day per cow from medium and small farm sizes, respectively [30].

This study's early daily milk yields from rural and peri-urban production systems are lower than the average early daily milk yields of 9.0 ± 3.9 and 9.0 ± 4.0 l per day per cow in urban and peri-urban dairy production systems, respectively [30]. Further, the average mid daily milk yields of 7.4 ± 2.7 and 7.0 ± 2.9 l per day per cow were reported in urban and peri-urban production systems, respectively [30], which was higher than the current results. The study showed that the average late daily milk yields in peri-urban production systems are comparable with 4.3 ± 1.9 and 4.4 ± 2.3 l for urban and peri-urban production systems, respectively in the central zone of Tigrai, Norther Ethiopia [30].

Crossbreed dairy cows had the least square means daily milk yield (DMY) of 8.35 ± 0.09 l per day per cow. This result is comparable with 8.45 ± 1.23 l per day per cow for crossbreed cows in Jimma town [11] and 7.61 l per day per cow for crossbreed cows in Hadiya Zone, Southern Ethiopia [38]. Further, this result is comparable to 7.39 ± 0.87 l daily milk yields for jersey crossbreeds, but less than 9.30 ± 0.76 l for Holstein crossbreeds in Nepal [27]. However, it is lower than the average DMY of 10.45 ± 0.07 l per cow in Ethiopia [14] and 9.5 ± 5.4 l per cow for crossbreed dairy cows in North Shoa Zone [15]. On the other hand, the average DMY of 11.6 ± 3.1 and 10.8 ± 2.4 l per cow were reported in Bishoftu and Akaki, respectively for crossbreed dairy cows [17]. The least squares means of DMY were 5.11 ± 0.10 and 5.18 ± 0.13 l per day per cow in rural and peri-urban production systems, respectively. Melku et al. [39] reported an average DMY of 8.7 ± 1 l per day per cow for crossbreed cows with 75% exotic blood levels in peri-urban production systems, which was higher than this study's findings.

The least square means DMY for local was 1.93 ± 0.14 l per day per cow. These findings are comparable with the average DMY of 2.2 l for local cows in the pre-urban dairy production system of Western Oromia [40], 1.6 ± 0.5 l for local cows in West Gojam Zone, Amhara Region, Ethiopia [39], 2.02 ± 0.8 l for local cows Walmera special zone of Oromia regional state, around Finfine [41] and 1.8 ± 0.045 l for local cows in Dawro Zone, Southern Ethiopia [28]. However, the least square means of DMY reported in this study is greater than 1.37 l per day per cow at the national level in Ethiopia for local cows [42]. This study's DMY levels for local cows are higher than the average DMY of 1.40 ± 0.06 and 1.12 ± 0.06 l per cow in midland and lowland, respectively in the Bako Tibe district west of Showa [20].

Lactation milk yield

The least square means lactation milk yields (LMY) for crossbreed dairy cows was 2203.61 ± 31.66 l per cow. Crossbreed dairy cows exhibited a higher LMY than local cows (Table 3). This could be explained by combining HFs' high milk yield potential with the adaptability and hardiness of local breeds. Moreover, this increased productivity is attributed to their larger body size, improved feed conversion efficiency and enhanced fertility. The study found a significant ($P < 0.0001$) difference between breeds, but no significant difference ($P > 0.05$) between production systems and breed interaction with production systems (Table 3). This finding is comparable to the average LMY of 2253.39 l per cow for Jersey crossbreds, whereas lower than 2936.36 l per cow for Holstein crossbreds [27]. Furthermore, this result is comparable to 2123.43+65.67 per cow for crossbred dairy cows in Gonder, Ethiopia [43] and 2155 ± 33 l per cow in the Arsi zone for crossbred dairy cows [44]. In this study, the least square means LMY was higher than the average LMY of 2042.11 l per cow in Jimma town [11] and 2057.16 l per cow in Hadiya Zone, Southern Ethiopia [38]. However, it was lower than the average LMY of 3208.56 ± 108.81 and 3031.56 ± 46.32 l per cow in Bishoftu, and Akaki, respectively [17] and 2913.78 ± 61.88 l per cow in Ethiopia [14] for crossbred dairy cows.

The least-square means of LMY (411.49 ± 48.95) resulting from local cows in this study is less than the native breed's LMY of 542.3 l per lactation per cow in the Oromia regional state West Shewa Zone [19]. In contrast, the least-square means value found was higher than the native cow LMY of 403.21+90.34 l in Gonder, Ethiopia [43] and 311.6 ± 43 l in West Gojam Zone, Amhara Region, Ethiopia [39]. Moreover, Melku et al. [39] found that crossbred dairy cows with 75% exotic blood had lower LMY in rural, peri-urban and urban production systems (595.3 ± 105, 784.1 ± 94 and 908.7 ± 244) than the current results. Melku et al. [39] found that local cows in rural, urban, and peri-urban production systems produced 139.7 ± 48, 253.2 ± 3, and 534.6 ± 5 l of milk per lactation, respectively, which is lower than current values. The amount of milk produced by a dairy cow during a specific lactation period, known as the lactation milk yield, is a crucial economic factor in dairy farming. It directly influences the farm business and the overall viability of dairy operations. Lactation milk yield can be influenced by various factors such as breed, management practices, feed quality and quantity, the number of lactations, persistence of peak production, and weather conditions. Hence, considering these factors is essential for improving milk production and achieving the best results.

Lactation length

The study indicated that lactation length (LL) differed significantly ($P < 0.0001$) between breeds, but did not significantly differ ($P < 0.05$) between production systems and breed interaction production systems. The least square means LL for crossbred and local dairy cows were 8.75 ± 0.09 and 7.03b ± 0.14 months, respectively. Crossbred dairy cows had longer LL than local cows. This study's least square means LL for crossbreed dairy cows is comparable to the average LL of 241.67 ± 26.22 days for crossbreds in Jimma town [11], 8.99 ± 0.14 months for crossbreds in Hadiya Zone, Southern Ethiopia [38] and 8.26 ± 0.19 months for crossbreds in Ethiopia [14]. However, this study's least square means of LL was shorter than the average LL of 303.31 days for Jersey crossbreds and 314.18 days for Holstein crossbreds in Nepal [27]. Further, this result is shorter than the average LL of 325.12+61.28 days for crossbred dairy cows in Gonder Ethiopia [43] and 9.9 ± 3.6 months for crossbred dairy cows in the North Shoa Zone [15]. Furthermore, the current finding is shorter than the LL in Bishoftu and Akaki, which were 276.6 ± 35.1 and 280.7 ± 19.3 days, respectively [17]. Moreover, the current results are lower than that of 9.03 ± .05 and 9.06 ± .16 months in midland and lowland, respectively [20]. A longer LL of 304.6 ± 40, 313.0 ± 50 and 292.8 ± 50 days were reported for 75% of exotic blood levels in rural, peri-urban and urban production systems, respectively [39]. This might be attributed to higher exotic blood levels.

The least square means LL for local cows was 6.86 ± 0.23 months. This result is shorter than the average LL of 260.5 ± 45 and 253.2 ± 3 days for local cows in rural and urban production systems, respectively, but shorter LL (204.2 ± 7 days) in peri-urban production systems [39]. However, the obtained least square means exceeded 7.89 ± 2.05 and 7.48 ± 1.69 months for peri-urban and urban dairy production systems, respectively [30]. Lactation length refers to the number of days a cow spends producing milk during a single lactation period. Total lactation production is the most important factor when selecting dairy animals. Cows that produce less milk typically have shorter lactation periods compared to those that produce more. Both genetic and environmental factors influence milk yield and lactation period. Various factors such as breed differences, management practices, environmental conditions, and feeding systems can affect the production performance of dairy cows. It is crucial to consider all of these factors when aiming to optimize the productivity and health of a dairy herd.

Variables	Nº	DEY (liter)	DmiY (liter)	DLY (liter)	DMY (liter)	LMY (liter)	LL (month)
Crossbreed*Rural	175	11.10 ± 0.15	8.13 ± 0.14	5.76 ± 0.10	8.33 ± 0.12	2218.89 ± 40.97	8.85 ± 0.12
Crossbreed*Peri-urban	126	10.74 ± 0.18	8.34 ± 0.16	6.02 ± 0.12	8.36 ± 0.14	2188.33 ± 48.28	8.65 ± 0.14
Local breed*Rural	96	2.65 ± 0.21	1.94 ± 0.18	1.09 ± 0.14	1.89 ± 0.16	411.64 ± 55.31	7.21 ± 0.16
Local breed*Peri-urban	45	2.86 ± 0.30	1.95 ± 0.27	1.12 ± 0.20	1.98 ± 0.23	411.34 ± 80.78	6.86 ± 0.23

Table 4: Mean ± SE production performances of dairy cows Breed*Production System.

The interaction effects do not differ (P > 0.05). DEY: Daily Early Yield; DmiY: Daily Mid Yield; DLY: Daily Late Yield; DMY: Daily Milk Yield; LMY: Lactation Milk Yield; LL: Lactation Length.

Conclusion and Recommendation

The reproduction and production performances of both Holstein Friesian X local breed and local breed cows were explored in the study areas. Crossbreed dairy cows showed better reproductive performance than local breeds in age at first service, age at first calving, days open, calving intervals and number of services per conception. Similarly, crossbreed dairy cows outperformed native breeds in terms of productivity. These better reproductive parameters boost herd productivity and economic profitability in crossbreed dairy cows compared to native breeds. This could be explained by crossbreed dairy cow's superior genetic capacity for reproduction and production and feed conversion efficiency, compared to native breeds. Crossbreed can be a valuable asset for dairy farmers seeking to increase milk production while maintaining adaptability and disease resistance. Furthermore, the findings of this study suggest that producers could enhance their local breeds for improved performance via crossbreeding. However, they must protect their native breeds without diluting their bloodlines with exotic breeds. The success of the dairy business rests on reproductive and production performance. Neglecting either of these factors can have serious consequences and pose a threat to the long-term sustainability and viability of the industry. Hence, this presents a valuable opportunity for farmers to improve their practices and increase their understanding of the factors that affect their animals.

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