

Effect of Stage of Lactation and Parity Number on Daily Milk Yield among Indigenous and Crossbred Cows in Jimma Zone, Ethiopia

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ABSTRACT

Milk production depends on factors such as breed of cows, stage of lactation and number of lactation. The aim of this study was to evaluate the effects of parity number and stage of lactation on daily milk yield (DMY) of indigenous and crossbred dairy cows reared under peri-urban and rural production systems in Jimma Zone, southwestern Ethiopia. A total of 32 milking cows with different lactation numbers and at different stages of lactation were selected for data collection. Of these, 16 were indigenous cows, while the remaining 16 were crossbred cows. The results showed that the average DMY significantly ($P < 0.01$) decreased with increasing stage of lactation. The mean DMY of indigenous cows during the early, mid, and late stages of lactation was 1.63 ± 0.10 , 1.27 ± 0.08 ; 0.54 ± 0.06 , 2.2 ± 0.10 ; and 1.89 ± 0.14 , 1.00 ± 0.05 L/cow/day in rural and peri-urban production systems, respectively. The corresponding values for crossbred cows were 8.18 ± 0.30 , 6.47 ± 0.27 , 5.36 ± 0.10 ; and 9.06 ± 0.34 , 8.00 ± 0.14 , 6.45 ± 0.31 L/cow, respectively. The results also showed that the mean DMY was significantly ($P < 0.01$) influenced by the number of lactations (parity). The overall average DMY of indigenous cows in the first, second, and third parity was 1.25 ± 0.043 , 1.43 ± 0.01 , and 1.55 ± 0.057 L/cow, respectively, in peri-urban and rural production systems, while the corresponding values for crossbred cows were 6.88 ± 0.098 , 7.29 ± 0.08 , and 7.60 ± 0.084 L/cow/day, respectively. The highest mean daily milk yield was obtained in the third parity, while the lowest was observed in the first parity for both breeds and production systems. The mean DMY of both breeds during different stages of lactation and parity numbers was significantly ($P < 0.01$) higher in the peri-urban production system than in the rural production system. Based on these findings, parity order and stages of lactation significantly influenced the DMY of both indigenous and crossbred dairy cows. In addition, the production system had a significant effect on milk yield. It could be concluded that parity and stage of lactation should be considered when designing nutritional interventions aimed at improving milk yield in lactating cows.

Vol No: 10, Issue: 04

Received Date: October 06, 2026

Published Date: October 30, 2026

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Citation: Abafita M, et al. (2026). Effect of Stage of Lactation and Parity Number on Daily Milk Yield among Indigenous and Crossbred Cows in Jimma Zone, Ethiopia. Mathews J Vet Sci. 10(4):117.

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Keywords: Dairy Cows, Crossbred, Indigenous, Parity, Daily Milk Yield, Stages of Lactation

INTRODUCTION

Livestock farming is an integral component of agriculture and rural livelihoods in Ethiopia, contributing about 17–25.3% of the national gross domestic product (GDP), 39–49% of agricultural GDP, and more than 50% of household incomes [1]. Moreover, livestock contributes about 12–15% of export earnings and provides 60–70% of employment [2]. Livestock production provides draught power, meat and milk for household consumption, income, and organic manure for crop production. Ethiopia has the largest cattle population in Africa, estimated at 65.35 million head, of which about 97.76% are indigenous breeds of different ecotypes. These indigenous cattle are generally kept for multiple purposes, including draught power, meat and milk production, and income generation. Crossbred and exotic breeds account for 1.91% and 0.32% of the total cattle population, respectively [3].

The number of dairy cows in Ethiopia is estimated at around 7.15 million, while the number of milking cows is about 12.57 million head [3]. Ethiopia's total annual milk production from approximately 7.5 million milking cows is estimated at 4.96 billion liters, with an average production of 1.48 liters/cow/day [4]. Smallholder dairy farmers contribute about 98% of the total milk production and represent approximately 85% of milk producers in the country [5].

In Ethiopia, smallholder dairy cattle farming contributes about 16.5% of GDP, 35.6% of agricultural GDP, 15% of export earnings, and 30% of employment [6,7]. According to Chanyalew [8], the dairy sub-sector alone contributes 63% of the overall value of ruminant output in the country. The dairy sub-sector is dominated by smallholder mixed crop–livestock farmers, agro-pastoralists, and pastoralists, who contribute more than 98% of the total milk production [9]. Despite the large number of dairy cattle in the country, their productivity remains low, and per capita milk consumption is also very low, at approximately 19 kg per year [10]. The low productivity of the dairy sector is attributed to several factors, including feed scarcity, limited land for forage production and farm expansion, diseases, limited access to improved genotypes, lack of access to credit, low productivity of indigenous dairy cows, inadequate or inefficient artificial

insemination services, low milk prices, labor shortages, and water scarcity [11].

Milk yield in dairy cows is influenced by various factors, including age, breed, stage of lactation, parity, genetic makeup, nutritional status, and genotype–environment interaction [12]. Ahmed et al. [12] further indicated that parity and stage of lactation have significant effects on milk yield. Milk yield generally increases during the early stages of lactation and subsequently decreases as lactation advances. An earlier study reported that total lactation milk yield increased with increasing lactation number [13]. Megersa [14] reported that the highest milk yield was recorded at the fourth parity, followed by the third parity. Similarly, Wondifraw et al. [15] observed that primiparous cows had the lowest milk production, whereas cows in the fifth parity had the highest daily milk yield. Mohamed [16] reported that milk yield increased with advancing lactation number up to the fourth parity and then decreased with a further increase in the number of lactations.

The stage of lactation also affects milk production. According to Agnihotri and Rajkumar [17], a higher peak milk yield was recorded during the early stage of lactation, whereas Mech et al. [18] reported that peak milk yield was recorded during the mid-stage of lactation. The effects of parity and stage of lactation on milk yield in crossbred and indigenous dairy cows have also been reported in Ethiopia [14,15,19]. However, studies examining the effects of parity and stage of lactation on daily milk yield under different production systems are limited.

Understanding the factors responsible for variation in daily milk yield is essential for dairy farmers when making decisions regarding breed selection and management practices. Therefore, the present study was aimed at assessing the effects of parity and stage of lactation on daily milk yield of crossbred and indigenous dairy cows kept under peri-urban and rural production systems in Dedo and Gomma districts of Jimma Zone, Oromia Regional State, Ethiopia.

RESEARCH METHODOLOGY

Study Area

The study was conducted in Dedo and Gomma districts of Jimma Zone, Oromia Regional State, Ethiopia. Gomma Woreda is located 397 km southwest of Addis Ababa and

approximately 50 km west of Jimma town (ARDO, 2003). The district extends between 7°40' and 8°04' north latitudes and 36°17' and 36°46' east longitudes. The annual mean rainfall of the area ranges from 800 to 2,000 mm, while the minimum and maximum annual temperatures range from 7°C to 12°C and 25°C to 30°C, respectively (ARDO, 2008).

Dedo district is located at approximately 7°24' north latitudes and 37° east longitudes. The altitude of the district ranges from 880 to 2,400 meters above sea level. The mean annual rainfall ranges from 1,200 to 2,800 mm, with a mean temperature of 20°C to 25°C. Accordingly, the annual average temperature ranges from 14°C to 20°C in the highlands and from 20°C to 25°C in the lowlands [20].

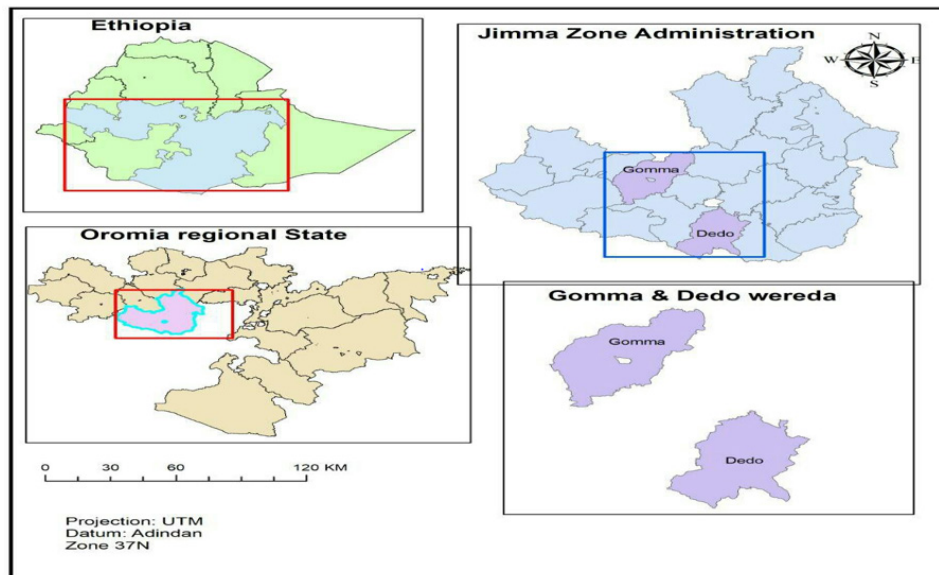


Figure 1: Map of the study area, Gomma and Dedo Woreda (Districts)

Study Design and Sampling

A total of 180 households participated in a survey on the productive and reproductive performance of indigenous and crossbred dairy cows in Dedo and Gomma districts (data not presented here). From these households, 30 that owned lactating dairy cows were identified, of which 15 owned crossbred cows and 15 owned indigenous cows. These households collectively owned 101 lactating dairy cows, comprising 55 indigenous and 46 crossbred cows. Of the 101 cows, 32 (16 indigenous and 16 crossbred) representing different lactation numbers and stages of lactation were purposively selected for monitoring and comparing daily milk yield.

Because of the lack of a regular milk-recording system, information on daily milk yield was collected through direct monitoring over a period of two months. The selected lactating cows included 16 indigenous and 16 crossbred cows from rural and peri-urban production systems, respectively. The selected lactating cows were stratified into three stages of lactation: early (1–2 months), mid (3–4 months), and late

(>5 months) stages of lactation for both indigenous and crossbred dairy cattle [21]. The cows were also categorized into three lactation numbers or parity groups (1st, 2nd, and 3rd parity).

Milk Yield Data Collection

Information on daily milk yield according to stage of lactation, breed, and parity was collected through the monitoring study. Daily milk yield data, including morning and evening milkings, were recorded by enumerators once a week on a test-day basis during the two-month recording period. Daily milk yield was calculated as the sum of the morning and evening milk yields recorded on each test day.

To stimulate milk letdown, calves were allowed to suckle their dams for a few minutes before milking and after each milking. The cows were then hand-milked. Milk consumed by the calves was not estimated. Therefore, the milk yields reported in this study represent milk offtake rather than total milk production. Milk yield was measured using a calibrated 1-L plastic jug.

Feeding Management of Dairy Cattle

The dairy cows depended mainly on natural pasture grazing. The animals were taken to natural pasture, either private or communal, early in the morning after milking, where they remained throughout the day and returned home just before sunset. Some farmers provided supplementary feed to their crossbred cows, including crop residues, grains, household leftovers, and non-conventional feed resources, whenever available.

Data Analysis

The collected data were analyzed using the Statistical Package for the Social Sciences (SPSS) software, version 20.0 (SPSS, 2014). Descriptive statistics, including means and standard errors, were computed. An independent-samples t-test was conducted to compare mean values between milk yield of the two dairy breeds and production systems. The data were presented as mean $\pm$ standard error (SE), and statistical significance was declared at $P < 0.05$.

RESULTS AND DISCUSSION

Effect of Stage of Lactation on Average Daily Milk Yield

Table 1 presents the average daily milk yield of crossbred and indigenous cows at different stages of lactation in the study area. The average daily yields in early, mid and late stages of lactation were 1.92 ± 0.10 and 8.62 ± 0.33 , 1.58 ± 0.12 and 0.77 ± 0.05 , and 5.9 ± 0.21 L for indigenous and crossbred cows, respectively. indigenous cows showed significantly ($p \leq 0.05$) lower daily milk yield in different stages of lactation.

The mean daily milk yield of indigenous dairy cows during the early, mid, and late stages of lactation were 1.63 ± 0.10 , 1.27 ± 0.08 , and 0.54 ± 0.06 L/cow in the rural production system, and 2.2 ± 0.1 , 1.89 ± 0.14 , and 1.00 ± 0.05 L/cow in the peri-urban production system, respectively. Indigenous cows in rural area showed significantly ($p \leq 0.05$) lower daily milk yield compared to peri-urban area in different stages of lactation.

The corresponding mean daily milk yield of crossbred dairy cows during the early, mid, and late stages of lactation were 8.18 ± 0.30 , 6.47 ± 0.27 , and 5.36 ± 0.10 L/

cow in the rural production system, and 9.06 ± 0.34 , 8.00 ± 0.14 , and 6.45 ± 0.31 L/cow in the peri-urban production system, respectively. Crossbred cows in rural area showed significantly ($p \leq 0.05$) lower daily milk yield compared to peri-urban area in different stages of lactation. The mean daily milk yields of indigenous cows obtained in the present study were lower than those reported by Megersa [14] and Melku [19]. Megersa [14] reported mean daily milk yields of 2.82, 2.57, and 1.55 L/cow/day during the early, mid, and late stages of lactation, respectively, while Melku [19] reported corresponding values of 3.38, 2.82, and 0.89 L/cow/day.

Similarly, the mean daily milk production of crossbred cows observed in the present study was lower than that reported by Adebabay [22], who recorded 10.96, 9.12, and 5.04 L/cow/day during the first, second, and third stages of lactation, respectively. Melku [19] also reported mean daily milk yields of 9.00, 7.21, and 4.40 L/cow/day during the early, mid, and late stages of lactation, respectively.

The results further showed that indigenous cows had significantly ($P < 0.05$) lower daily milk yields than crossbred cows at the same and different stages of lactation across the two production systems. These findings indicate that breed and production system influenced daily milk yield at different stages of lactation. Other factors, such as feed availability, management practices, disease, season, and year of calving, may also affect daily milk yield at different stages of lactation.

The higher milk yield observed at all stages of lactation among both crossbred and indigenous cows kept under the peri-urban production system could be attributed to better feeding, management, and health-care practices, as well as better access to production inputs and services, compared with the rural production system. The higher daily milk yield of crossbred cows compared with indigenous cows in the present study may not only be associated with their higher genetic potential but could also be related to better management practices. Crossbred cows may receive better feeding, including supplementary feed, as well as improved housing and health-care services.

Table 1. Effects of lactation stage on daily milk yield of crossbred and indigenous cows under peri-urban and rural dairy production systems in the study area (mean $\pm$ SE).

Breed	Production System	Stage of Lactation			Overall	LS
		Early	Mid	Late		
Indigenous	Rural	1.63 $\pm$ 0.1 ^{Aa}	1.27 $\pm$ 0.08 ^{Ab}	0.54 $\pm$ 0.06 ^{Ac}	1.14 $\pm$ 0.08 ^a	**
	Peri-urban	2.2 $\pm$ 0.1 ^{Aa}	1.89 $\pm$ 0.14 ^{Bb}	1.00 $\pm$ 0.05 ^{Ac}	1.7 $\pm$ 0.10 ^b	**
	Overall	1.92 $\pm$ 0.10	1.58 $\pm$ 0.12	0.77 $\pm$ 0.05 ^c	1.42 $\pm$ 0.09	**
	LS	NS	**	NS		
Crossbred	Rural	8.18 $\pm$ 0.3 ^{Aa}	6.47 $\pm$ 0.27 ^{Ab}	5.36 $\pm$ 0.1 ^{Ac}	6.67 $\pm$.21 ^a	**
	Peri-urban	9.06 $\pm$ 0.34 ^{Ba}	8.00 $\pm$ 0.14 ^{Bb}	6.45 $\pm$ 0.31 ^{Bc}	7.83 $\pm$ 0.26 ^b	**
	Overall	8.62 $\pm$ 0.33	7.23 $\pm$ 0.18	5.9 $\pm$ 0.21	7.25 $\pm$ 0.24	**
	LS	**	**	**	**	

Different uppercase superscripts (A and B) within the same column indicated sig differences ($p \leq 0.05$) in daily milk yield of cows between production systems and means within the same row with different lowercase superscript (a, b and c) differ significantly ($p < 0.05$) in daily milk yield between stages of lactation; **= significant different at $p < 0.01$; NS=Not significant different; LS= level of significance

Effects of Parity Number on Average Daily Milk Yield

Table 2 presents the mean daily milk yield (DMY) of dairy cows at different parity number under rural and peri-urban production systems in the study area. The average daily milk yields first, second and third numbers of lactation were 1.25 $\pm$ 0.043 and 6.88 $\pm$ 0.01, 1.43 $\pm$ 0.01 and 7.29 $\pm$ 0.08, and 1.55 $\pm$ 0.06 and 7.60 $\pm$ 0.08L for indigenous and crossbred cows, respectively. Indigenous cows showed significantly ($p \leq 0.05$) lower daily milk yield in different parity numbers. The average DMY of indigenous cows was significantly ($P < 0.01$) lower in all parities compared to crossbred cows. The overall mean DMY of indigenous cows in the first, second, and third parity order were 0.99 $\pm$ 0.03 and 1.51 $\pm$ 0.06, 1.19 $\pm$ 0.04 and 1.67 $\pm$ 0.00 and 1.28 $\pm$ 0.07 and 1.83 $\pm$ 0.05 L/cow in the rural and peri-urban production systems respectively. The results showed that parity number had a significant ($P < 0.05$) effect on DMY in both rural and peri-urban production systems. In both breeds and production systems, the highest DMY was recorded in the third parity compared to the second and first parities.

The average DMY of crossbred cows in the first, second, and third party were 6.22 $\pm$ 0.15 and 7.54 $\pm$ 0.04, 6.77 $\pm$ 0.06 and 7.81 $\pm$ 0.10, and 7.02 $\pm$ 0.02 and 8.15 $\pm$ 0.13 L/cow, in the rural and peri-urban production system, respectively. The mean DMY varied significantly ($P < 0.01$) among different parities and production systems. The highest DMY was recorded in the third parity compared with the first and second parities.

The findings of the present study are consistent with those of Sourabh et al. [23], who found that multiparous cows produced higher DMY than primiparous cows. Similarly, Megersa [14] reported that high DMY was recorded in the fourth parity, while Wondifraw et al. [15] found that primiparous cows had the lowest milk production and cows in the fifth parity had the highest DMY. Mohamed [16] also reported that milk yield increased with advancing lactation number up to the fourth parity. Generally, maximum milk yield is expected when cows have reached full maturity, usually around the third or fourth lactation [24].

The increase in milk yield with advancing parity may be attributed to the increase in udder size and the development of milk-secreting glands as the number of parities increases. Pal et al. [25] reported that, in mature animals, the mammary parenchyma is more developed due to optimum hormonal levels. These hormones influence the proliferation and death of mammary cells as well as their secretory activity.

The results of this study further showed that crossbred cows had significantly ($P < 0.05$) higher DMY than indigenous cows at the same and different parities across the production systems. Overall, the findings indicate that parity and production system influenced the DMY of dairy cows. The higher DMY observed in cows under the peri-urban production system compared with those under the rural production system could be attributed to better access to quality feed, improved management practices, and better health-care services.

Table 2. Effect of parity number on daily milk yield of indigenous and crossbred cows under rural and peri-urban dairy production systems (mean $\pm$ SE)

Breed	Production System	Parity			Overall
		1 st	2 nd	3 rd	
Indigenous	Rural	0.99 $\pm$ 0.03 ^{Aa}	1.19 $\pm$ 0.04 ^{bA}	1.28 $\pm$ 0.07 ^c	1.15 $\pm$ 0.05 ^A
	Peri-urban	1.51 $\pm$ 0.06 ^{aB}	1.67 $\pm$ 0.00 ^{abB}	1.83 $\pm$ 0.05 ^{bb}	1.67 $\pm$ 0.04 ^B
	Overall	1.25 $\pm$ 0.043	1.43 $\pm$ 0.01	1.55 $\pm$ 0.06	1.41 $\pm$ 0.16
	LS	***	***	***	***
Crossbred	Rural	6.22 $\pm$ 0.15 ^{aA}	6.77 $\pm$ 0.06 ^{bA}	7.02 $\pm$ 0.02 ^{ba}	6.71 $\pm$ 0.15 ^A
	Peri-urban	7.54 $\pm$ 0.04 ^{aB}	7.81 $\pm$ 0.10 ^{aB}	8.15 $\pm$ 0.13 ^{bb}	7.84 $\pm$ 0.05 ^B
	Overall	6.88 $\pm$ 0.01	7.29 $\pm$ 0.08	7.60 $\pm$ 0.08	7.25 $\pm$ 0.09
	LS	***	***	***	***

Different uppercase superscripts (A and B) within the same column indicated sig differences ($p \leq 0.05$) in daily milk yield of cows between production systems and means within the same row with different lowercase superscript (a, b and c) differ significantly ($p < 0.05$) in daily milk yield between parity; ***=significant different at $p < 0.001$; LS= level of significance

Overall Effect of Stage of Lactation and Number of Parity on Daily Milk Yield

Table 3 presents a comparison of the average daily milk yield of crossbred and indigenous cows across different stages of lactation and parities. The results revealed that the overall mean daily milk yield across the different stages of lactation was significantly higher ($p < 0.01$) in crossbred cows than in indigenous cows. Furthermore, crossbred cows exhibited a highly significant difference ($p < 0.001$) in average daily milk yield compared with indigenous cows at the same parity and

stage of lactation. The average daily milk yield of crossbred cows also differed highly significantly ($p < 0.001$) among the different parities.

These findings are consistent with those reported by Shuiep et al. [26]. The present results indicate that crossbred cows produced higher daily milk yields across different parities and stages of lactation than indigenous cows. The higher milk production of crossbred cows may be attributed to their genetic potential for milk production, coupled with the relatively better management practices provided to them.

Table 3. Overall comparison of mean daily milk yield (L) between crossbred and indigenous cows across different lactation stages and parity numbers (mean $\pm$ SE).

Production System	Breed	Milk Yield			Overall
		Stage of Lactation			
		Early	Mid	Late	
Rural	Indigenous	1.92±0.10 ^{aA}	1.58±0.12 ^{bA}	0.77±0.05 ^{cA}	1.42±0.09 ^A
	Crossbred	8.62±0.33 ^{bb}	7.23±0.18 ^{bb}	5.9±0.2 ^{bb}	7.25±0.24 ^B
	Sig.	***	***	***	***
Peri-urban	Parity	First parity	Second parity	Third parity	
	Indigenous	1.25±.043 ^{aA}	1.43±.01 ^{bA}	1.55±.06 ^{cA}	1.41±.16 ^A
	Crossbred	6.88±0.01 ^{aB}	7.29±0.08 ^{bb}	7.60±.08 ^{cB}	7.25±.09 ^B
	LS	***	***	***	***

Different uppercase superscripts (A and B) within the same column indicated sig differences ($p \leq 0.05$) in daily milk yield of cows between production systems and means within the same row with different lowercase superscript (a, b and c) differ significantly ($p < 0.05$) in daily milk yield between stages of lactation; ***=significant different at $p < 0.001$; LS= level of significance

CONCLUSIONS AND RECOMMENDATION

It can be concluded that both stage of lactation and parity order significantly affected the daily milk yield of indigenous and crossbred dairy cows. Crossbred cows had significantly ($p \leq 0.05$) higher daily milk yields than indigenous cows at the same stage of lactation and within the same parity. In both indigenous and crossbred cows, significantly ($p \leq 0.05$) higher daily milk yield was observed during early lactation than during the second and third stages of lactation. Furthermore, cows in the third parity showed significantly ($p \leq 0.01$) higher milk yield than those in the second and first parities. Moreover, in both indigenous and crossbred cows, daily milk yield was significantly ($p \leq 0.05$) higher in the third parity than in the second parity. Similarly, crossbred cows had significantly ($p \leq 0.05$) higher average daily milk yields across different parities than indigenous cows. The results imply that rearing more crossbred cows can improve productivity and profitability when supported by optimal management practices. The observed differences in milk yield between crossbred and indigenous cows may also be associated with differences in management practices, particularly feeding and other husbandry conditions. Therefore, the present study suggests that improving management practices, especially the provision of adequate and appropriate supplementary feeding, is important for maintaining higher milk production throughout lactation. Such management should consider both the stage of lactation and parity of the cows to optimize milk yield and improve the productivity of dairy cattle.

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