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Meta-analysis for Milk Production performance Traits of Jersey cross, 50% HF and 75% HF Cross Dairy Cattle in Ethiopia

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ABSTRACT

This review evaluated the milk production performance of crossbred dairy cattle, focusing on Jersey cross, 50% HF cross, and 75% HF cross breeds in Ethiopia. Data from 131 crossbred cattle performance records were analyzed using SAS (version 9.0) software. The overall means for milk production traits were 6.30±1.20 liters for daily milk yield (DMY), 326.13±25.99 days for lactation length (LL), and 1947.13±444.57 liters for lactation milk yield (LMY). Genetic group significantly (p<0.05) influenced milk production performance traits. The 75% HF cross exhibited superior performance in DMY and LMY, while the 50% HF cross showed better performance in LL. Phenotypic correlations among milk production traits were positive and low, with values of 0.439 between LMY and DMY, 0.352 between LMY and LL, and 0.034 between DMY and LL. The results indicate that 75% HF crossbred cows generally outperformed 50% HF and Jersey crosses in milk production traits, with higher proportions of exotic genes correlating with increased milk yield. However, the recommendation of 75% HF crosses for milk production in low-input systems should be carefully considered. Efficient management practices, including genetic improvement, quality feed supplementation, and health management, are essential for optimizing milk production performance. A balanced crossbreeding strategy, integrating genetic improvement with sustainable management, is essential for enhancing dairy productivity and resilience in Ethiopia.

Key word: Daily milk yield, exotic genes, Jersey cross, milk production performance

Introduction:

Dairy production plays a pivotal role in enhancing food security, improving nutrition, and boosting the incomes of smallholder farmers in developing countries like Ethiopia. However, the productivity of indigenous cattle breeds in Ethiopia remains low, primarily due to genetic limitations and suboptimal management practices (Mekonnen et al., 2020). To address this challenge, crossbreeding local cattle with high-yielding exotic breeds such as Holstein Friesian (HF) and Jersey has been widely promoted as a strategy to improve milk production while maintaining some level of adaptation to local environments (Tadesse et al., 2021). Crossbreeding aims to combine the high productivity of exotic breeds with the adaptability and disease resistance of indigenous cattle, thereby creating genotypes that are better suited to the needs of smallholder dairy systems (Gebreyohannes et al., 2019).

Despite the potential benefits, the performance of crossbred cattle varies significantly depending on the proportion of exotic genes, management practices, and environmental conditions (Assefa et al., 2022). higher levels of exotic inheritance (75% HF cross) have been associated with increased milk yields, but they may also require more intensive management, including improved feeding, health care, and heat stress mitigation (Derese, 2020). On the other hand, lower levels

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of exotic inheritance (50% HF cross or Jersey cross) may offer a better balance between productivity and adaptability, particularly in resource-constrained systems (Haile et al., 2021). Understanding the milk production performance of different crossbred genotypes is therefore critical for designing effective breeding programs and providing evidence-based recommendations to farmers.

Recent studies have emphasized the importance of evaluating key milk production traits such as daily milk yield (DMY), lactation length (LL), and lactation milk yield (LMY) to assess the performance of crossbred cattle under varying production systems (Tadesse et al., 2021). Additionally, phenotypic correlations among these traits provide valuable insights into the potential for indirect selection and genetic improvement (Gebreyohannes et al., 2019). However, there is a lack of comprehensive reviews that systematically compare the milk production performance of different crossbred genotypes, particularly in the context of Ethiopian smallholder dairy systems.

This review aims to fill this gap by evaluating the milk production performance of three crossbred genotypes Jersey cross, 50% HF cross, and 75% HF cross based on data collected from published and unpublished sources. By analyzing key milk production traits and their phenotypic correlations, this study seeks to identify the most suitable genotypes for smallholder dairy systems in Ethiopia. Furthermore, the findings of this review will contribute to the development of sustainable crossbreeding strategies that enhance milk production while addressing the challenges of feed availability, health management, and environmental adaptation. Therefore, the objective of this review was to evaluate comparative performance for milk production traits of Jersey cross, 50% HF and 75% HF cross dairy cattle in Ethiopia.

Materials and methods

Study Design and Data Collection

This review was conducted to evaluate the milk production performance of crossbred dairy cattle, specifically focusing on Jersey cross, 50% HF cross, and 75% HF cross genotypes in Ethiopia. Data were collected from both published and unpublished sources, including research articles, technical reports, and institutional records. A total of 131 milk production performance records of crossbred dairy cattle were compiled, covering key milk production traits such as daily milk yield (DMY), lactation length (LL), and lactation milk yield (LMY) Appendix Tables. The data spanned various agro-ecological zones and management systems to ensure representativeness.

Data Analysis

The collected data were analyzed using statistical software SAS (version 9.0). Descriptive statistics, including means and standard deviations, were calculated for each milk production trait. The effect of genetic group (Jersey cross, 50% HF cross, and 75% HF cross) on milk production performance was assessed using one-way analysis of variance (ANOVA). Phenotypic correlations among milk production traits (DMY, LL, and LMY) were also computed to understand the relationships between these traits and their potential implications for selection and breeding programs.

Variables and Measurements

The milk production traits evaluated in this study were defined as follows

Daily Milk Yield (DMY): The average amount of milk produced per day during a lactation period, measured in liters.

Lactation Length (LL): The total duration of a lactation period, measured in days.

Lactation Milk Yield (LMY): The total amount of milk produced over a complete lactation period, measured in liters.

Statistical Models

Statistical Model for Analysis of milk production traits

$$Y_{in} = \mu + Y_i + e_{in}$$

Where:

Yin = DMY, LL and LMY trait of i^{th} Animal group

μ = overall mean

Yi = the effect of i^{th} Animal group (I = Jersey cross, 50% HF cross and 75% HF cross)

E_{in} = random error associated with each observation

Results and Discussion

Daily milk yield (DMY)

The overall mean daily milk yield (DMY) of 6.30±1.20 liters observed in this review aligns closely with findings from previous studies conducted in Ethiopia and other tropical regions. Haile et al. (2009a) reported a DMY of 6.3±0.1 liters for 75% HF crossbred cows, while Demeke et al. (2004) found a similar value of 6.2±0.17 liters for 50% Jersey x Borena (F1) crosses. Additionally, Million and Tadelle (2003) reported a DMY of 6.28±0.52 liters for 87.5% HF x Barca crosses, further supporting the consistency of the current findings. These similarities suggest that crossbred dairy cattle in Ethiopia exhibit relatively stable milk production performance across different genetic groups and management systems.

However, the DMY reported in this review was lower than the 9.91 liters observed for HF x Fogera crosses by Sena et al. (2014) but higher than the 4.18±5 liters reported for F2 Jersey crosses by Kefena et al. (2006). These variations can be attributed to differences in genetic composition, environmental conditions, and management practices. Higher exotic gene proportions, such as in HF x Fogera crosses, often result in increased milk yields due to the superior genetic potential of exotic breeds (Assefa et al., 2022). Conversely, lower yields in F2 Jersey crosses may reflect the dilution of exotic genes and the influence of less favorable environmental conditions, such as limited feed resources and poor health management (Derese, 2020).

The coefficient of variation (CV) of 19.04% for DMY indicates moderate variability in milk production among the crossbred cows. This variability may be influenced by factors such as parity, feed availability, and production systems. Tadesse (2014) and Kefale (2018) noted that DMY tends to increase with parity, as older cows often have better body condition and more efficient nutrient utilization. Additionally, Haile et al. (2009a) highlighted the impact of seasonal changes and declining pasture productivity on milk yields, particularly in smallholder systems where feed resources are often limited.

The highly significant ($p<0.05$) effect of genetic group on DMY underscores the importance of breed composition in determining milk production performance. In this review, 75% HF crosses exhibited the highest DMY, consistent with findings by Tadesse et al. (2021), who reported that higher proportions of exotic genes generally correlate with increased milk yields. However, the suitability of high-grade crosses (75% HF) in low-input systems must be carefully considered, as they may require more intensive management and higher-quality feed resources to achieve their genetic potential (Gebreyohannes et al., 2019).

In conclusion, the DMY of crossbred dairy cattle in Ethiopia is influenced by a combination of genetic, environmental, and management factors. While higher exotic gene proportions can

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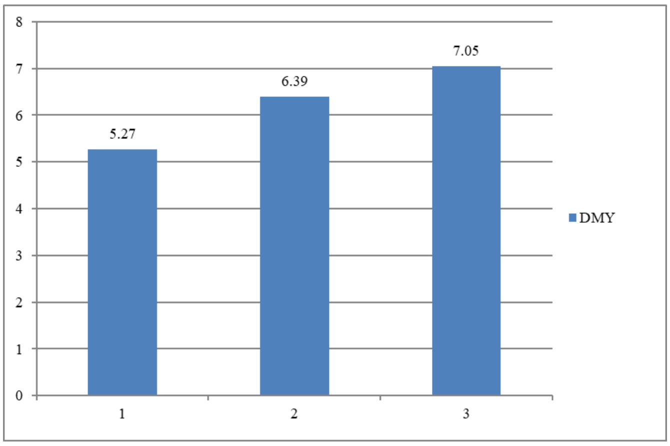
enhance milk production, their implementation must be balanced with the availability of resources and the adaptability of the animals to local conditions. Future research should focus on optimizing crossbreeding strategies and improving management practices to maximize the productivity and sustainability of smallholder dairy systems.

Table 1: Means, standard deviation minimum, maximum and CV of Daily Milk Yield (DMY)

Effect / **Genetic groups**	**N**	**DMY Mean±SD (Liters)**	**Minimum**	**Maximum**	**CV (%)**
Jersey cross	11	5.27±0.63	4.18	6.20	11.95
50% HF	19	6.39±1.27	4.81	9.91	19.87
75% HF	13	7.05±0.83	5.98	8.78	11.77
Overall	43	6.30±1.20	4.18	9.91	19.04

Figure 1: Daily Milk yield (DMY)



1= Jersey cross, 2= 50% HF and 3=75% HF

Lactation Length (LL)

The overall mean lactation length observed in this review was 326.13±25.99 days, with a coefficient of variation (CV) of 7.96%, indicating moderate variability across the studied genetic groups (Jersey cross, 50% HF, and 75% HF crossbred cows). The minimum and maximum lactation lengths recorded were 241.65 days and 374.05 days, respectively. These findings align closely with earlier reports, such as Million and Tadelle (2003), who documented a lactation length of 326±11 days for 50% HF × Barca crosses under on-station management. However, discrepancies were observed when compared to other studies. Kefale (2018) reported a significantly longer lactation length (374.05±7.24 days) for 75% HF crosses in a research center, while Belay et al. (2012) noted a shorter duration (241.65±26.22 days) for Zebu × HF crosses under on-farm conditions. These variations highlight the interplay of genetic, environmental, and management factors influencing lactation traits.

Genetic composition significantly affected lactation length ($p < 0.05$), with higher HF genetic proportions correlating to longer lactations. 75% HF crosses exhibited lactation lengths closer to those reported by Kefale (2018) and Million and Tadelle (2003) for similar genetic groups. This aligns with the well-documented superiority of Holstein Friesian genetics in enhancing milk yield persistence and lactation duration (Mekonnen et al., 2020). Jersey crossbreds, however, showed shorter lactations, likely due to breed-specific differences in lactation curves and metabolic efficiency (Tarekegn et al., 2021). The moderate CV (7.96%) further underscores the role of genetic uniformity within crossbred groups in stabilizing lactation performance.

The divergence in lactation lengths across studies underscores the critical role of non-genetic factors. the shorter lactation reported by Belay et al. (2012) for Zebu × HF cows under on-farm conditions likely reflects suboptimal nutrition, healthcare, and stress associated with smallholder systems. Conversely, the extended lactations observed in research settings (Kefale, 2018) emphasize the benefits of controlled feeding, disease prevention, and improved herd management. Recent studies corroborate this, demonstrating that feed quality and energy balance directly influence lactation persistency, particularly in high-producing crossbreds (Deresa et al., 2022). Such findings suggest that genetic potential can only be fully expressed under supportive management regimes.

Recent investigations reinforce the complex interplay of genetics and environment. A 2022 meta-analysis by Asrat et al. highlighted that 75% HF crosses in Ethiopia achieved lactation lengths exceeding 350 days when provided with balanced rations and veterinary care, whereas limited feed resources reduced this to 280–300 days. Similarly, Getahun et al. (2023) reported that Jersey crosses in Kenya exhibited shorter lactations (<300 days) under heat stress conditions, underscoring the breed's sensitivity to environmental stressors. These observations align with the present review's findings, where the minimum lactation length (241.65 days) likely reflects stressors absent in controlled research environments.

This review reaffirms that lactation length in crossbred dairy cows is shaped by both genetic and environmental factors. While higher HF genetic proportions improve lactation persistence, the realization of this potential hinges on optimal management. The variability across studies underscores the need for context-specific breeding and management recommendations. Future research should employ genomic tools to disentangle genetic effects from environmental noise and evaluate the economic viability of crossbreeding strategies under diverse production systems.

Table 2: means, standard deviation minimum, maximum and CV of Lactation Length (LL)

Effect / Genetic groups	**N**	**LL Mean±SD (Days)**	**Minimum**	**Maximum**	**CV (%)**
Jersey cross	11	319.05±22.17	270.30	343.00	6.95
50% HF	18	317.88±26.85	241.65	348.00	8.44
75% HF	14	342.30±21.04	303.12	374.05	6.15
Overall	43	326.13±25.99	241.65	374.05	7.96

N= Number of observation, LL= Lactation Length and CV= Coefficient of Variation

Lactation Milk Yield (LMY)

The overall mean LMY was 1947.13±444.57 liters, with a coefficient of variation (CV) of 22.83%, indicating moderate variability in milk yield across the studied populations. This result aligns closely with the findings of Demeke et al. (2004), who reported 1956±133 liters for 75% Jersey × Borena cattle under on-station management. However, the mean LMY observed here was notably higher than values reported by Melku (2016) for 50% HF × Local (631.69±222.98

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liters) and 75% HF × Local (762.71±147.42 liters) crosses under on-farm conditions, as well as Sisay (2015), who documented 1293.01±23.70 liters for Jersey × Horro crosses at Bako Agricultural Research Center.

Conversely, the aggregated LMY from this review was lower than values reported in several other studies. Kefale (2018) recorded 2957.46±72.98 liters for 75% Holstein Friesian (HF) crosses, while Demeke et al. (2004) and Sena et al. (2014) reported 2528±141 liters (75% HF × Borena) and 2705.43 liters (Holstein × Fogera), respectively, under on-farm systems. Similarly, Kefena et al. (2006) observed 2480.4±7 liters for 75% Friesian crosses in on-station settings. These disparities in LMY across studies likely reflect differences in genetic composition, management practices, and environmental conditions.

Genetic group exerted a significant ($p > 0.05$) influence on LMY among Jersey crosses, 50% HF, and 75% HF crossbred cows. However, the variations in reported LMY values across studies underscore the multifactorial nature of milk production. Key factors contributing to these differences include breed-specific genetic potential, divergent feeding regimes, climatic adaptability, production systems (on-station vs. on-farm), and seasonal calving patterns (Kefale, 2018; Tadesse, 2014). For example, on-station herds often benefit from controlled nutrition and healthcare, potentially inflating yields compared to smallholder on-farm systems, where resource limitations prevail. Additionally, environmental stressors, such as heat stress in tropical climates, may suppress productivity in high-grade exotics compared to hardier crossbreds adapted to local conditions.

The CV of 22.83% further highlights the variability inherent in smallholder production systems, where inconsistent management and feed availability likely contribute to fluctuating yields. This aligns with broader observations in developing countries, where dairy improvement programs face challenges in standardizing inputs across diverse agroecological zones.

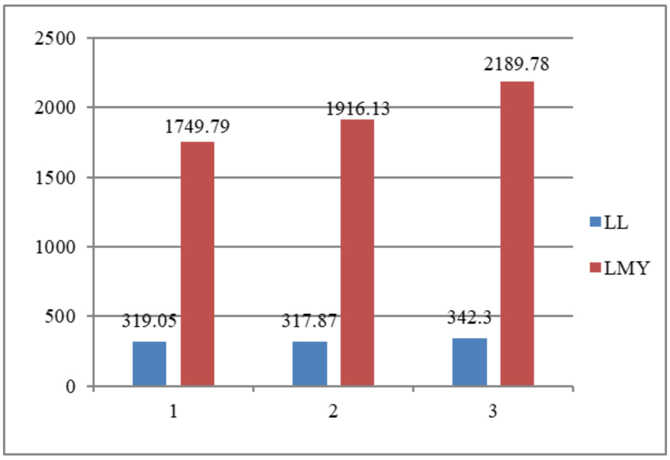
In conclusion, while genetic selection for higher-grade exotic crosses (75% HF) may enhance LMY, the interplay of genetic potential, environmental adaptation, and management practices must be optimized to achieve sustainable gains. Future breeding strategies should prioritize balanced genetic improvement tailored to local production contexts, coupled with investments in nutrition, health, and climate-resilient management practices.

Table 3: Means, standard Deviation Minimum, Maximum and CV of Lactation Milk Yield (LMY)

Effects / Genetic group	N	LMY Mean±SD (Liters)	Minimum	Maximum	CV (%)
Jersey cross	13	1749.79±279.58	1293.01	2364.70	15.97
50% HF	19	1916.13±439.29	631.69	2705.43	22.93
75% HF	13	2189.78±499.56	762.71	2957.46	22.81
Overall	45	1947.13±444.57	631.69	2957.46	22.83

N= Number of observation, LMY= Lactation Milk Yield and CV= Coefficient of Variation

Figure 2: Lactation Length (LL) and Lactation Milk Yield (LMY)



1= Jersey cross, 2= 50% HF and 3=75% HF

Phenotypic Correlation

Correlations measure the strength of relationships between variables, with higher values indicating stronger associations (Bourdon, 2000). In the context of dairy cattle improvement, understanding correlations between milk production traits is critical for predicting indirect responses to selection. Phenotypic correlations among milk production traits in the present review revealed moderate to strong positive relationships. Lactation milk yield (LMY) exhibited positive correlations with daily milk yield (DMY) and lactation length (LL), with values of 0.439 and 0.352, respectively. These findings align with Kefale (2018), who similarly reported strong associations between LMY, DMY, and LL.

The observed phenotypic correlations underscore the interdependence of milk production traits. The positive relationship between LMY and DMY suggests that selection for higher daily yields could improve total lactation performance. Similarly, the correlation between LMY and LL highlights the importance of sustained lactation periods in achieving higher cumulative milk output. These patterns emphasize the potential for simultaneous genetic improvement in multiple milk production traits through targeted breeding strategies.

Table 4: Phenotypic correlations of milk production traits

Traits	Pearson Correlation		
	DMY	LL	LMY
DMY			
LL	0.034		
LMY	0.439**	0.352*	

** Correlation is significant at the 0.01 level.
* Correlation is significant at the 0.05 level.

Conclusion

This review highlights the significant impact of genetic composition and phenotypic relationships on the milk production traits of crossbred dairy cattle in Ethiopia. The 75% HF cross demonstrated superior daily and total lactation milk yield, whereas the 50% HF cross had a longer lactation period, indicating a trade-off between productivity and persistence. Phenotypic correlations among milk production traits were positive but moderate, with the strongest association between lactation milk yield and daily milk yield, underscoring the potential for indirect selection in breeding programs. While increased exotic gene proportions enhance milk yield, their effectiveness in smallholder systems depends on optimized feeding, health care, and adaptive management practices. A balanced crossbreeding strategy, integrating genetic improvement with

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sustainable management, is essential for enhancing dairy productivity and resilience in Ethiopia.

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Appendix Table

Appendix Table 1: Daily Milk Yield of crossbred dairy cows with different genetic group in Ethiopia

No	breed/ genotype	DMY (L)	Study sites	Source
1	50% F1 Friesian	6.69±0.08	on station	Kefale, 2018
2	50% F2 Friesian	5.66±0.16	on station	Kefale, 2018
3	50% F3 Friesian	5.02±0.19	on station	Kefale, 2018
4	50% HF	6.0±0.1	on station	Haile *et al*., 2009a
5	50% HF x Local	7.34±2.61	on farm	Melku, 2016
6	50% HF x Barca	7.21±0.26	on station	Million and Tadelle 2003

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7	50%F1 Friesian	7.14±0.06	on station	Tadesse, 2014
8	50%F2 Friesian	5.70±0.12	on station	Tadesse, 2014
9	50%F3 Friesian	5.05±0.15	on station	Tadesse, 2014
10	50%HF x Borena	6.36±0.30	on station	Million and Tadelle 2003
11	50%HF x Borena	6.4±0.06	on station	Gebregziabhere *et al*., 2013
12	50%HF x Borena (F1)	7.1±0.17	on station	Demeke *et al*., 2004
13	50%HF x Borena (F2)	5.4±0.24	on station	Demeke *et al*., 2004
14	50%HF x Horro	5.7±0.10	on station	Gebregziabhere *et al*., 2013
15	50%Jersey x Borena	5.6±0.08	on station	Gebregziabher *et al*., 2013
16	50%Jersey x Borena (F1)	6.2±0.17	on station	Demeke *et al*., 2004
17	50%Jersey x Borena (F2)	4.5+0.24	on station	Demeke *et al*., 2004
18	50%Jersey x Horro	4.9±0.10	on station	Gebregziabher *et al*., 2013
19	75% F1 Friesian	8.70±0.17	on station	Kefale, 2018
20	75% F2 Friesian	6.72±0.37	on station	Kefale, 2018
21	75% Friesian	6.95±6	on station	Kefena *et al*., 2006
22	75% HF	6.3±0.1	on station	Haile *et al*., 2009a
23	75% HF x Local	8.78±1.69	on farm	Melku, 2016
24	75% HF x Barca	7.15±0.28	on station	Million and Tadelle 2003
25	75% Jersey	4.9±4	on station	Kefena *et al*., 2006
26	75%HF x Borena	6.92±0.25	on station	Million and Tadelle 2003
27	75%HF x Borena	7.2±0.32	on station	Demeke *et al*., 2004
28	75%HF x Borena	7.0±0.11	on station	Gebregziabhere *et al*., 2013
29	75%HF x Borena	6.91±0.25	on station	Tadesse, 2014
30	75%HF x Horro	6.8±0.23	on station	Gebregziabhere *et al*., 2013
31	75%Jersey x Borena	6.1±0.31	on station	Demeke *et al*., 2004
32	75%Jersey x Borena	5.7±0.17	on station	Gebregziabher *et al*., 2013
33	75%Jersey x Horro	5.5±0.23	on station	Gebregziabher *et al*., 2013
34	87.5% HF x Barca	6.28±0.52	on station	Million and Tadelle 2003
35	87.5%HF x Borena	5.98±0.50	on station	Million and Tadelle 2003
36	F1 Friesian	5.6±8	on station	Kefena *et al*., 2006
37	F1 Jersey	5.17±7	on station	Kefena *et al*., 2006
38	F2 Friesian	4.81±5	on station	Kefena *et al*., 2006
39	F2 Jersey	4.18±5	on station	Kefena *et al*., 2006
40	Friesian x Borena	5.88±0.05	on station	Gebregziabhere *et al*., 2014
41	HFx Fogera	9.91	on farm	Sena *et al*., 2014
42	Jersey x Borena	5.21±0.05	on station	Gebregziabher *et al*., 2014
43	Jersey x GH	7. 30±0.16	on farm	Wondossen *et al*., 2018
44	Zebu X HF	8.45±1.23	on farm	Belay *et al*.,2012

Appendix Table 2: Lactation length of crossbred dairy cows with different genetic group in Ethiopia

No	breed/ genotype	LL (days)	Study sites	Source

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1	50% F1 Friesian	343.62±3.56	on station	Kefale, 2018
2	50% F2 Friesian	319.42±6.68	on station	Kefale, 2018
3	50% F3 Friesian	319.25±8.37	on station	Kefale, 2018
4	50% HF	337±3	on station	Haile *et al.*, 2009a
5	50% HF x Local	310.91±41.83	on farm	Melku, 2016
6	50% HF x Barca	326±11	on station	Million and Tadelle 2003
7	50%F1 Friesian	332.54±2.82	on station	Tadesse, 2014
8	50%F2 Friesian	298.68±5.17	on station	Tadesse, 2014
9	50%F3 Friesian	299.90±6.46	on station	Tadesse, 2014
10	50%HF x Borena	328±13	on station	Million and Tadelle 2003
11	50%HF x Borena	337.2±3.6	on station	Gebregziabher *et al.*, 2013
12	50%HF x Borena (F1)	348±6	on station	Demeke *et al.*, 2004
13	50%HF x Borena (F2)	308±9	on station	Demeke *et al.*, 2004
14	50%HF x Horro	321.0±5.5	on station	Gebregziabher *et al.*, 2013
15	50%Jersey x Borena	315.3±0.6	on station	Gebregziabher *et al.*, 2013
16	50%Jersey x Borena (F1)	343±6	on station	Demeke *et al.*, 2004
17	50%Jersey x Borena (F2)	304±9	on station	Demeke *et al.*, 2004
18	50%Jersey x Horro	303.8±5.8	on station	Gebregziabher *et al.*, 2013
19	75% F1 Friesian	374.05±7.24	on station	Kefale, 2018
20	75% F2 Friesian	303.12±15.73	on station	Kefale, 2018
21	75% Friesian	356.43±6	on station	Kefena *et al.*, 2006
22	75% HF	351±6	on station	Haile *et al.*, 2009a
23	75% HF x Local	303.42±46.25	on farm	Melku, 2016
24	75% HF x Barca	360±12	on station	Million and Tadelle 2003
25	75% Jersey	341±4	on station	Kefena *et al.*, 2006
26	75%HF x Borena	358±11	on station	Million and Tadelle 2003
27	75%HF x Borena	331±12	on station	Demeke *et al.*, 2004
28	75%HF x Borena	343.2±6.3	on station	Gebregziabher *et al.*, 2013
29	75%HF x Borena	331.02±11.12	on station	Tadesse, 2014
30	75%HF x Horro	360.7±12.7	on station	Gebregziabher *et al.*, 2013
31	75%Jersey x Borena	337±11 D	on station	Demeke *et al.*, 2004
32	75%Jersey x Borena	302.8±9.8	on station	Gebregziabher *et al.*, 2013
33	75%Jersey x Horro	329.0±12.9	on station	Gebregziabher *et al.*, 2013
34	87.5% HF x Barca	351±22	on station	Million and Tadelle 2003
35	87.5%HF x Borena	341±20	on station	Million and Tadelle 2003
36	93.75% HF	328.3±5.50	on station	Wubshet, 2018
37	F1 Friesian	340.64±10	on station	Kefena *et al.*, 2006
38	F1 Jersey	333.37±7	on station	Kefena *et al.*, 2006
39	F2 Friesian	337±5	on station	Kefena *et al.*, 2006
40	F2 Jersey	330±5	on station	Kefena *et al.*, 2006

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41	HFx Fogera	273	on farm	Sena *et al*., 2014
42	Jersey x GH	9.01±0.37	on farm	Wondossen *et al*., 2018
43	Zebu X HF	241.65±26.22	on farm	Belay *et al*.,2012

Appendix Table 3: Lactation Milk Yield of crossbred dairy cows with different genetic group in Ethiopia

No	breed/ genotype	LMY (L)	Study sites	Source
1	50% F1 Friesian	2203.23±38.13	on station	Kefale, 2018
2	50% F2 Friesian	1697.09±71.82	on station	Kefale, 2018
3	50% F3 Friesian	1522.67±90.07	on station	Kefale, 2018
4	50% HF	2019±26	on station	Haile *et al*., 2009a
5	50% HF x Local	631.69±222.98	on farm	Melku, 2016
6	50% HF x Barca	2316±98	on station	Million and Tadelle 2003
7	50%F1 Friesian	2369.95±26.04	on station	Tadesse, 2014
8	50%F2 Friesian	1681.24±47.66	on station	Tadesse, 2014
9	50%F3 Friesian	1542.38±59.57	on station	Tadesse, 2014
10	50%HF x Borena	2088±118	on station	Million and Tadelle 2003
11	50%HF x Borena	2031±20.9	on station	Gebregziabher *et al*., 2013
12	50%HF x Borena (F1)	2355±71	on station	Demeke *et al.*, 2004
13	50%HF x Borena (F2)	1928±108	on station	Demeke *et al.*, 2004
14	50%HF x Horro	1836±31.6	on station	Gebregziabher *et al*., 2013
15	50%Jersey x Borena	1788±26.5	on station	Gebregziabher *et al*., 2013
16	50%Jersey x Borena (F1)	2092±75	on station	Demeke *et al.*, 2004
17	50%Jersey x Borena (F2)	1613±107	on station	Demeke *et al.*, 2004
18	50%Jersey x Horro	1621±33.1	on station	Gebregziabher *et al*., 2013
19	75% F1 Friesian	2957.46±72.98	on station	Kefale, 2018
20	75% F2 Friesian	2027.16±152.15	on station	Kefale, 2018
21	75% Friesian	2480.4±7	on station	Kefena *et al*., 2006
22	75% HF	2182±4	on station	Haile *et al*., 2009a
23	75% HF x Local	762.71±147.42	on farm	Melku, 2016
24	75% HF x Barca	2373±105	on station	Million and Tadelle 2003
25	75% Jersey	1673.94±4	on station	Kefena *et al*., 2006
26	75%HF x Borena	2336±96	on station	Million and Tadelle 2003
27	75%HF x Borena	2528±141	on station	Demeke *et al.*, 2004
28	75%HF x Borena	2240±35.9	on station	Gebregziabher *et al*., 2013
29	75%HF x Borena	2292.36±102.55	on station	Tadesse, 2014
30	75%HF x Horro	2184±72.8	on station	Gebregziabher *et al*., 2013
31	75%Jersey x Borena	1956±133	on station	Demeke *et al.*, 2004
32	75%Jersey x Borena	1832±56.0	on station	Gebregziabher *et al*., 2013
33	75%Jersey x Horro	1724±73.9	on station	Gebregziabher *et al*., 2013
34	87.5% HF x Barca	2189±183	on station	Million and Tadelle 2003
35	87.5%HF x Borena	1915±163	on station	Million and Tadelle 2003

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36	F1 Friesian	1908.06±11	on station	Kefena *et al*., 2006
37	F1 Jersey	1725.46±7	on station	Kefena *et al*., 2006
38	F2 Friesian	1622±5	on station	Kefena *et al*., 2006
39	F2 Jersey	1380±5	on station	Kefena *et al*., 2006
40	Friesian x Borena	1907.6±15.1	on station	Gebregziabher *et al*., 2014
41	holistian X fogera	2705.43	on farm	Sena et al., 2014
42	Jersey x Borena	1684.1±17.6	on station	Gebregziabher *et al*., 2014
43	Jersey x GH	2364.70±85.06	on farm	Wondossen *et al*., 2018
44	Jersey x Horro	1293.01±23.70	on station	Sisay, 2015
45	Zebu X HF	2042.11	on farm	Belay *et al*.,2012

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