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Milk yield and reproductive performances of crossbred dairy cows with different genotypes in Ethiopia: a review paper

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Abstract Crossbreeding for improving milk yield and reproductive performances had started and implemented been long in Ethiopia in different locations. The present study focused on reviewing and generating compiled information about the status (potential) of milk yield and reproductive performances of crossbred dairy cows, which have been done at different stations and farm conditions in different eras. Review results of milk production and reproductive performances in Ethiopia varied greatly from one genotype to another. The on-station lactation milk yield and lactation length were ranged from 1293 to 2957 kg and 303 to 374 days, respectively, whereas the on-farm review results were within the values of on-station conditions. The on-station reproductive performances had also obtained in the range from 25.5 to 30.3 for age at first service (AFS), 28.5 to 46.9 for age at first calving (AFC), 351 to 546 for calving interval (CI), 76 to 243 for days open (DO) and 1.3 to 2.7 for the number of service per conception (NSC), respectively. The on-farm review results for reproductive performances had also within the range of on-station conditions. Among the genotypes, the 50% F_1 and 75% Holstein Friesian first generations were considered suitable for milk production parameters, whereas Jersey crosses, especially 50% F_1 are recommended for better reproductive performances. The on-station development of 50% F_2, F_3, and 75% second generations showed low milk production and reproductive performances and the likelihood of producing synthetic breed in this step did not give us a promising result. Regardless of blood level and genotype difference, the performance of on-farm crossbred cows was almost similar to on-station experimental cows. Crossbred cows were affected by non-genetic factors like year, season, and parity, depending on the breed and study location. In general, crossbred cows have good milk yield and reproductive performances compared to indigenous (local) breeds. However, crossbred animals could not exploit their maximum potentials because animals are subjected to different environmental effects.

Keywords: crossbred, genotype, indigenous breed, milk yield, reproductive performance

1. Introduction

In the tropics, dairy farming based on indigenous cattle alone would not be a quick and suitable option to meet the increasing demand for milk and milk products (Mohamed et al 2007). The most favored alternative so far has been crossbreeding. Most crossbreeding improvements in the tropics, particularly in Ethiopia, have been widely practiced to boost the milk production of indigenous cattle. There have been persistent attempts to produce different crossbreeding genotypes. The milk production and reproductive performances of dairy cattle are closely associated. Reproductive failure has an evident negative influence on milk production and farm income and determines a dairy farming operation (Arbel et al 2001). However, crossbreeding for maintaining and improving reproductive performance, as a breeding goal has been less attention. Authors (Cunningham and Syrstad 1987; Hammoud et al 2010) were highlighted the importance of measuring reproductive performance in cows especially the economic benefit of cows to produce a calf every year to producers.

Nevertheless, the ultimate goal in dairy production is to undertake an economically efficient milk production, which is influenced by the reproductive efficiency of the cows. In the long-term crossbreeding program, different genotypes were produced in the country. The present review was focused on generating information about the status (potential) of milk yield and reproductive performances of crossbred dairy cows with different genotypes maintained at different on-station and farm conditions in Ethiopia. The data used for this review was collected from different on-station and on-farm research results (authors' publications) across the country in the past.

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2. Milk production traits

The milk production performance of dairy cattle is usually measured by milk yield per lactation, average daily milk yield, lactation length, lactation persistency, milk composition, and lifetime production (VanRaden 2003; Zewudu et al 2013).

2.1. Lactation milk yield

Obtaining a high level of milk production from dairy cows depends on the genetic situation of the animal and environmental factors. Among the environmental factors, the quantity and quality of available feed resources relative to the maintenance cost of the animals are most reliable.

Previous research results (Table 1) indicated that in Ethiopia, milk production performance of crossbred dairy cows could not achieve 10 or more liters of daily milk yield and 3000 liters of lactation milk yield with any one of the genotypes in the last fifty years at on station or on-farm condition even crosses were milked more than standard lactation period. However, recent reports indicated that more than 9 (close to 10) liters of daily milk yield were obtained from crossbred dairy cows at the on-farm level (Kefyalew and Damtie 2015; Mebrahtom and Hailemichael 2016). In this regard, on-farm crossbred cows showed better milk yield performance than on-station animals, as crossbred animals were subjected to different experiments.

The on-station lactation milk yield had ranged from 1293-2957 kg. The lower value was from Horro x Jersey reported by Sisay (2015) at Bako research center. The highest value was from 75% HF x Borena reported by Kefale et al (2020) at Holetta research center.

Milk yield was drastically dropped in the second filial generation (F_2) crosses though the proportion of local and exotic genes is similar to that of first filial generation ($F_{1)}$ crosses. From the review in the literature (Table 1), lactation milk yield was reduced by 427 liters (18%) from F_1 Holstein Friesian (HF) x Borena to its F_2 and 479 liters (22.9 %) from 50 % F_1 Jersey x Borena to its F_2 counterparts. This might be the breakdown of gene (epistasis gene action) in the F_2 generations. Million and Tadelle (2003a) reported that the 50% F_1 HF x Barca cows had a higher lactation and daily milk yield than F_1 HF x Borena and F_1 HF x Horro cows, and this superiority tended to be repeated in 75% and 87.5% crosses. In another study (2003b), these authors also reported the superiority of 50% F_1 over 75% first-generation crosses (6 liters and 5.7 liters), respectively, for daily milk yield. Kefena et al (2006a) and Haile et al (2009a), on their finding, had shown a consistent increase in milk yield with increasing levels of exotic genes from 50% F_1 to 100% Holstein blood level.

On the other hand, Addisu (2013) and Kefyalew and Damtie (2015) reported a contradicted result that their milk yield performance was reduced as exotic blood level increased. The same is true for Million and Tadelle (2003b), where the milk production dropped if the exotic blood level exceeded 75% first generations. These could be attributed to animal management, the expression of gene action in each crossbred animal, and the geographical location in which the experiments had been done. Therefore, it can be concluded that the best genotype did not work in all environments of Ethiopia.

Milk production performances of crossbred dairy cattle (undefined blood level) at the on-farm level are also different in different parts of Ethiopia. Belay et al (2012) evaluated the performance of zebu and Holstein Friesian crossbred dairy cows in Jimma town and reported 2333 liters of milk per lactation and 7.01 ± 2.73, 5.55 ± 2.83 and 3.50 ± 1.64 liters of milk per day per cow, at 1st, 2^{nd,} and 3rd parties, respectively. Kefyalew and Damtie (2015) reported an average daily milk yield of 6.27 and 6.90 kg around Gondar, 6.95 and 6.46 kg around Bahir Dar from 50% and 75% exotic blood levels, respectively. Another study carried out by Melku et al (2017) in North West Ethiopia obtained 7.3 ± 3 and 8.8 ± 2 kg of DMY with 310.9 ± 42 and 303.4 ± 46 days of lactation length from 50% and 75% crossbred cows.

2.2. Lactation length

In most modern dairy farms, a lactation length of 305 days is commonly accepted as a standard (Msangi et al 2005). However, such a standard lactation length might not work for smallholder dairy cows in which the lactation length is extended considerably in most cases. The profitability of short or extended lactation length depends on various factors, including the lactation length persistency. Crossbred cows had milked more than 305 days in Ethiopia and fulfilled the recommendation of (Msangi et al 2005). The 75% genotypes, particularly 75% HF x Barca and 75% HF x Horro, had higher lactation lengths than others.

Beyond the gene level, various non-genetic factors (feed, season, year and parity) influence milk production and lactation performances of dairy cows. Lactation milk yield and lactation length were significantly influenced by season and parity (Mohamed et al 2007; Belay et al 2012; Kumar et al 2014). According to Zewudu et al (2013) report, in India, maximum and minimum production of milk was obtained during winter (December to February) and summer (March to May) seasons, respectively. Fadlelmoula et al (2007), Kefena et al (2011), and Yohannes et al (2016) also reported that the influence of parity on milk yield and lactation length was significant and reflected progressive trend from 1st to 4th parities on lactation milk yield. In addition to these, some authors (Million and Tadelle 2003a; Djoko et al 2003 and Zewudu et al 2013) highlighted that lactation milk yield, daily milk yield, and lactation length were significantly affected by the year of calving.

Table 1 Milk production performances of crossbred dairy cows with different genotypes in Ethiopia.

Genotype	Milk production traits			Sources
	LMY	LL	DMY	
50% HF x Barca	2316 ± 98	326 ± 11	7.21 ± 0.26	Million and Tadelle (2003a)
50%HF x Borena	2088 ± 118	328 ± 13	6.36 ± 0.30	Million and Tadelle (2003a)
75% HF x Barca	2373 ± 105	360 ± 12	7.15 ± 0.28	Million and Tadelle (2003a)
75%HF x Borena	2336 ± 96	358 ± 11	6.92 ± 0.25	Million and Tadelle (2003a)
87.5% HF x Barca	2189 ± 183	351 ± 22	6.28 ± 0.52	Million and Tadelle (2003a)
87.5%HF x Borena	1915 ± 163	341 ± 20	5.98 ± 0.50	Million and Tadelle (2003a)
50%HF x Borena (F_2)	1928 ± 108	308 ± 9	5.4 ± 0.24	Demeke et al (2004a)
75%HF x Borena	2528 ± 141	331 ± 12	7.2 ± 0.32	Demeke et al (2004a)
Jersey x Borena (F_1)	2092 ± 75	343 ± 6	6.2 ± 0.17	Demeke et al (2004a)
Jersey x Borena (F_2)	1613 ± 107	304 ± 9	4.5 ± 0.24	Demeke et al (2004a)
75% Jersey x Borena	1956 ± 133	337 ± 11	6.1 ± 0.31	Demeke et al (2004a)
F_1 Friesian	1908.1±11	340.6±10	5.6 ± 8	Kefena et al (2006a)
F_1 Jersey	1725.46 ±7	333.4 ± 7	5.17±7	Kefena et al (2006a)
F_1 Simmental	1898 ± 5	327 ± 5	5.27±5	Kefena et al (2006a)
F_2 Friesian crosses	1622 ± 5	337 ± 5	4.81±5	Kefena et al (2006a)
F_2 Jersey crosses	1380 ± 5	330 ± 5	4.18±5	Kefena et al (2006a)
75% Friesian crosses	2480.4 ± 7	356.4 ± 6	6.95±6	Kefena et al (2006a)
75% Jersey crosses	1673.94 ± 4	341 ± 4	4.9±4	Kefena et al (2006a)
50% HF x Borena	2019 ± 26	337 ± 3	6.0±0.1	Haile et al (2009a)
62.5% HF x Borena	1918 ± 51	341 ± 6	5.7 ± 0.1	Haile et al (2009a)
75% HF x Borena	2182 ± 4	351 ± 6	6.3±0.1	Haile et al (2009a)
87.5% HF x Borena	2366 ± 91	355 ± 11	6.9 ± 0.1	Haile et al (2009a)
50% HF x Borena	2031 ± 20.9	337 ± 3.6	6.4±0.06	Gebregziabhere et al (2013)
75% HF x Borena	2240 ± 35.9	343 ± 6.3	7.0±0.11	Gebregziabhere et al (2013)
50% Jersey x Borena	1788 ± 26.5	315 ± 0.6	5.6±0.08	Gebregziabhere et al (2013)
75% Jersey x Borena	1832 ± 56.0	302.8 ± 9	5.7±0.17	Gebregziabhere et al (2013)
50% HF x Horro	1836 ± 31.6	321 ± 5	5.7±0.10	Gebregziabhere et al (2013)
75% HF x Horro	2184 ± 72.8	360 ± 12	6.8±0.23	Gebregziabhere et al (2013)
50% Jersey x Horro	1621 ± 33.1	303.8 ± 5	4.9±0.10	Gebregziabhere et al (2013)
75% Jersey x Horro	1724 ± 73.9	329 ± 12	5.5±0.23	Gebregziabhere et al (2013)
50% HF x Borena	1907.6±15	-	5.88±0.05	Gebregziabhere et al (2014)
50% Jersey x Borena	1684.1±17	-	5.21±0.05	Gebregziabhere et al (2014)
50% HF x Borena (F1)	2203.2±38	343.6±4	6.69±0.09	Kefale et al (2020)
50% HF x Borena (F2)	1697.1±71	319.4±7	5.66±0.16	Kefale et al (2020)
50% HF x Borena (F3)	1522.7±90	319.3±8	5.02±0.19	Kefale et al (2020)
75% HF x Borena (Fg)	2957.5±73	374±7	8.7±0.17	Kefale et al (2020)
75% HF x Borena (Sg)	2027±152	303.1±16	6.7±0.37	Kefale et al (2020)

LMY: lactation milk yield; LL: lactation length; DMY: daily milk yield; HF: Holstein Friesian; F_1: 1st filial generation; F_2: 2nd filial generation; F_3: 3rd filial generation; F_g: 1st generation for 75% crosses; S_g: 2nd generation for 75% crosses

3. Reproductive traits

Reproductive performance does not usually refer to a single trait but a combination of many traits. The most common indicators of reproductive performance as reported by many authors are age at first service, age at first calving, calving interval, days open, number of services per conception, and other fertility traits.

3.1. Age at First Service

Age at first service (AFS) is when heifers attain body condition and sexual maturity for accepting service for the first time. AFS signals for the beginning of heifer's reproductive and productive, influences both the female's productivity and reproductive life, and then influences her lifetime calf crop. A substantial delay in attaining sexual maturity may mean a severe economic loss due to the cow's additional, non-lactating, unproductive period over several months (Belay et al 2012). Genotype, nutrition, and other environmental factors influence age at first service. Good feeding and management probably heifers that grow faster and will cycle earlier and exhibit behavioral estrus (Kollalpitiya et al 2012).

Studies on reproductive performances of crossbred cows conducted under different production systems in Ethiopia demonstrated the different overall mean value of age at first service (AFS), which had ranged from 27 to 40.9 months at on station and 25.5 to 30.3 months at on-farm conditions.

On station study report by Haile et al (2009b) mean age at first service obtained from 50%, 62.5%, 75%, and 87.5% crosses were 27±0.7, 28±1, 28±0.9, and 28 ± 1.2 months, respectively. Gebeyehu et al (2005) reported a mean value of 36.8 ± 0.8 months from Fogera with Holstein crosses at Andasa livestock research center. Wassie et al (2015) studied Holstein Friesian and its crosses with Borena and Arsi at Agarfa agricultural and educational College found 30.47 ± 0.85 and 33.62 ± 0.71 months from HF x Borena and HF x Arsi, respectively.

On-farm survey-based studies done by Aregawi (2013), Alemshet (2014), Megerssa (2016), and Melku (2016) in different parts of Ethiopia (urban, peri-urban, and smallholder production systems) and reported an average AFS value of 30.3±0.42, 25.5±0.21, 26.83±0.54 and 29.52±3.96 months, respectively from different crossbred cows.

The influence of season and year on the AFS trait reported by authors in Ethiopia differed. The season was not affected, but calving year exerted a significant effect on age at first service trait (Gebeyehu et al 2005; Yosef 2006; Belay 2014 and Berhanu and Chakravarty 2014). However, Mengistu et al (2016) obtained a significant effect of season on AFS. This might be associated with the breed, geographical location, disease manifestation, and nutritional factor differences.

3.2. Age at First Calving

First calving marks the beginning of cows in calf and milk production. Age at first calving is closely related to the rearing intensity and impacts generation interval and response to selection in a breeding program (Mukasa Mugerewa 1989). Under a controlled breeding system, heifers are usually mated when they are mature enough to withstand the stress of parturition and lactation. It is recommended that heifers calve between 23 and 25 months of age, which is considered optimum that increases the dairy business profitability (Hammoud et al 2010). Concerning genotype differences, Beaverly (2015) study indicated that the most profitable age at first calving might differ to some degree between breeds, and the study reveals that the most profitable first calving age for Holstein and Jersey is 22 months. In contrast, for Ayrshire and Brown Swiss, it is 23 months. Previous works in Ethiopia had not reported in the range 22-25 months which both authors recommended ((Hammoud et al 2010; Beaverly 2015) either on station or on-farm conditions (Table 2).

The available on-station review results, which focused on different genotypes, had shown that AFC ranged from 28.5-46.9 months, which depends on the breed formation of each genotype and geographical location of the study areas. For example, as shown below in table 2, F_1 Jersey x Arsi had 9.6, 16.8, and 18.4 months early, first calved than F_1 HF x Arsi, F_1 Jersey x Local, and F_1 Jersey x Borena, respectively. Compared with the F_1 and F_2 generations, study reports on AFC also had variable results. It had unfortunate that Million et al (2006) reported F_2 Jersey x Borena and F_2 HF x Local had decreased AFC by 12.7 and 7.87 months compared to their F_1 counterparts. However, Demeke et al (2004b) and Getahun et al. (2019) reported an increase of AFC from F_1 to F_2 genotype. According to Kefena et al (2006a) report, F_1 Jersey crosses had 2.85 months shorter AFC than F_1 Friesian crosses and F_2 Jersey crosses had 4.49 months shorter AFC compared to their F_2 Friesian counterparts.

On-farm reports on age at first calving of crossbred dairy cattle had recorded higher values than on-station conditions in the ranges from 34-52 months. These might be depending on the crossbred type, exotic blood level, production system, and the available management systems of the crossbred cows at farmer condition. For instance, a study conducted by Solomon et al (2009) found that the crossbred cows performed higher AFC (52±2.5 months) under a smallholder management system. In addition to this, the values of 39.6±0.40 months were reported by Aregawi (2013), 34.8±0.21 months by Alemshet (2014), 35.87±0.10 months by Megerssa (2016), and 40.88±5.51 months by Melku (2016) for the same trait in urban, peri-urban and smallholder production systems. Wassie et al (2015) reported that Friesian × Borena crosses significantly shorter ($P < 0.05$) AFC than Friesian × Arsi crosses with an estimated overall mean value of 39.49 ± 0.83 months and 42.84±0.84 months, respectively.

In their previous studies on dairy cattle performance, authors reported mixed results for the influence of season and year on age at first calving trait. Season and year of calving significantly influenced AFC (Yosef 2006; Deriba 2012; Mengistu et al 2016). According to Yosef (2006) and Deriba (2012), in the dry season (October to January), Jersey heifers were attained earlier AFC than other seasons (short and main rain) in the year. However, the season of calving was no significant effect on AFC reported by (Belay 2014; Berhanu and Chakravarty 2014; Wassie et al 2015).

Table 2 Age at First Service, Age at First Calving and Calving Interval of crossbred dairy cows with different genotypes in Ethiopia.

Genotype	Reproductive traits			
	AFS(month)	AFC(month)	CI (days)	Sources
50% J x Arsi (F_1)	-	28.5 ± 1.3	351.2 ± 10.9	Negussie et al (1998)
50% J x Local (F_1)	-	39.50 ± 8	459.00 ± 9	Kefena et al (2006a)
50% J x Arsi	-	-	435.9 ± 14.9	Negussie et al. (1999)
50% J x Local (F_1)	-	45.32 ± 2.7	417.02±16.35	Million et al (2006)
50%J x Borena (F_1)	-	46.91 ± 3.8	-	Million et al (2006)
50% J x Borena (F_1)	-	35.4 ± 0.5	408 ± 6	Demeke et al (2004b)
50% J x Local (F_2)	-	44.07 ± 5	515 ± 5	Kefena et al (2006a)
50% J x Borena (F_2)	-	39.2 ± 0.6	430 ± 10	Demeke et al (2004b)
50%J x Borena (F_2)	-	34.25 ± 4.6	-	Million et al (2006)
75% J x Local	-	42.52 ± 5	528.06 ± 5	Kefena et al (2006a)
75% J x Borena	-	37.7 ± 0.7	426 ± 11	Demeke et al (2004b)
50% HF x Zebu (F_1)	-	-	397.5 ± 12.5	Negussie et al (1998)
50% HF x Local (F_1)	-	43.77 ± 4.2	438.9±10.49	Million et al (2006)
50% HF x Borena (F_1)	-	36.0 ± 0.4	417 ± 6	Demeke et al (2004b)
50% HF x Local (F_1)	-	42.35 ± 9	477.77 ± 12	Kefena et al (2006a)
50% HF x Arsi (F_1)	-	29.2 ± 1.4	358.1 ± 10.4	Negussie et al (1998)
50% HF x Borena (F_1)	28.3 ± 0.52	38.70 ± 0.53	461.17 ± 6.06	Getahun et al (2019)
50% HF x Arsi	-	38.1 ± 1.5	440.8 ± 7.7	Negussie et al (1999)
50% HF x Zebu	-	38.6 ± 1.1	481.9 ± 11.1	Negussie et al (1999)
50% HF x Local (F_2)	-	48.56 ± 5	512.6 ± 5	Kefena et al (2006a)
50% HF x Local(F_2)	-	35.91 ± 1.3	494.66± 5.45	Million et al (2006)
50% HF x Borena (F_2)	-	39.5 ± 0.6	435 ± 10	Demeke et al (2004b)
50% HF x Borena (F_2)	36.33±0. 87	46.13 ± 0.91	500.8±13.7	Getahun et al (2019)
50% HF x Local (F_3)	-	41.91 ± 1.8	457.01±29.08	Million et al (2006)
50% HF x Local (F_3)	34.31 ± 1.08	45.99 ± 1.12	471.74±17.8	Getahun et al (2019)
62.5% HF x Borena	-	38.5 ± 1	426 ± 18	Demeke et al (2004b)
75% HF x Zebu	-	37.5 ± 0.7	479 ± 9.6	Negussie et al (1999)
75% HF x Arsi	-	41 ± 0.9	491.4 ± 14.1	Negussie et al (1999)
75% HF x Local	-	41.29 ± 9	546.40 ± 9	Kefena et al (2006a)
75% HF x Local (F_g)	-	45.60 ± 2.6	479.23±12.92	Million et al (2006)
75% HF x Local (F_g)	-	40.77 ± 1.2	438.72±29.97	Million et al (2006)
75% HF x Local (F_g)	32.49 ± 0.86	43.97 ± 0.89	517.84±14.5	Getahun et al (2019)
75% HF x Local (S_g)	31.6 ± 1.60	41.48 ± 1.69	385.44±34.1	Getahun et al (2019)
75% HF x Borena	-	36.7 ± 0.7	444 ± 13	Demeke et al (2004b)
HF x (J x Arsi)	-	35.2 ± 0.9	422.9 ± 18.3	Negussie et al (1999)
crossbred	25.6	36.2	17.8 months	Emebet and Zeleke, (2007)
HF x Local	-	38.8 ± 0.5	-	Negussie et al (1999)
HF x Fogera	36.8 ± 0.8	-	-	Gebeyehu et al (2005)
HF x Borena	40.9 ± 0.33	-	475 ± 2.84	Berhanu et al (2011)
HF x Arsi	33.62 ± 0.71	42.84 ± 0.84	475.48 ± 3.44	Wassie et al (2015)
HF x Borena	30.47 ± 0.85	39.49 ± 0.83	476.36 ± 4.73	Wassie et al (2015)
HF x Borena	31.33 ± 0.44	41.08 ± 0.44	405.50 ± 3.32	Mengistu et al (2016)

HF = Holstein Friesian; J = Jersey; Local = non descriptive breed; F_g= first generation; $S_{g=}$ second generation

3.3. Calving Interval

Calving interval (CI) was reported to indicate the period between two successive calving. The calving interval was subdivided into two major periods: the calving to conception and the gestation periods. The latter is fixed in length, while the former varies depending on the type of breed and nutritional status of the cows. Calving interval varies slightly due to breed, calf sex, calf size, dam age, year, and month of calving. In most dairy industries, the calving interval of 12-13 months was considered optimal and was achieved when the calving to conception interval (days open) was less than 85-105 days (Keeling et al 1992; Arbel et al 2001). The reasonably short calving intervals of 12-13 months indicate an optimum combination of good management and sound physiological condition of the cow.

The available on-station review results on calving interval had ranged between 351-546 days (table 2). Jersey x Arsi (F_1) had the shortest calving interval, while 75% HF x Local had the longest calving interval (table 2). Other genotypes had somewhat around the modest value of these two extremes. Like age at first calving, authors had reported an increasing calving interval from F_1 to F_2 generations (Demeke et al 2004b; Kefena et al 2006b; Million et al 2006; Getahun et al 2019).

Million and Tadelle (2003a) studied that involved six genotypes originated from Barca and Borena crosses with HF and reported mean calving interval of 400±14, 400±14, 448±16, 436±15, 498±30 and 464±24 days from 50% HF x Barca, 50% HF x Borena, 75% HF x Barca, 75% HF x Borena, 87.5% HF x Barca and 87.5 HF x Borena, respectively. The estimated calving interval for Borena and Friesian crossbred cows with different genotypes reported by Haile et al (2009b) were 422 ± 10, 446 ± 12, 443 ± 11 and 443±21 days for 50%, 62.5%, 75%, and 87.5%. Another study by Sisay (2015) reported 13.43±0.17 months from Horro x Friesian and 12.76 ± 0.26 months from Horro x Jersey at Bako agricultural research center, which was somewhat lower values compared to others.

Review results from on-farm survey studies in urban, peri-urban, and smallholder production systems in different parts of Ethiopia revealed that the overall average value of calving interval for crossbred dairy cows were 453±45 days, 14.2±0.15 months, 16.51±3.39 months, and 437.8 ± 0.04 days (Solomon et al 2009; Aregawi 2013; Megerssa 2016; Melku 2016) with unknown genotype. The review result of calving interval obtained from on-farm was within the values reported at on-station conditions, which ranges from 437-495 days.

Apart from the level of exotic gene and production systems, other non-genetic factors (year, season, and parity) have been considered a great influence on calving interval traits. However, reports on the extent of the effect of these factors (year and parity) were variable. On station Studies Haile et al (2009b), Wassie et al (2015), and Mengistu et al (2016) reported that calving interval had been influenced by year of calving and parity. However, Belay (2014) reported the non-significant effect of year and party on this trait.

As shown from different on station or on-farm reports, the majority of study reports on calving interval had not laid in the optimal range (12-13 months), which was recommended by (Keeling et al 1992; Arbel et al 2001) except some 50% F_1 Barca, Borena, Arsi, and Horo cross with Friesian and Jersey. Other genotypes like 50% F_2, 75% first and/or second generations with any breed combinations had seen as longer or extended CI. The increased (extended) calving interval is undesirable, particularly in a production system where there is a high demand for pregnant or lactating heifer. However, Österman and Bertilsson (2003) suggested that by combining a longer calving interval with increased milking frequency, daily milk production from one calving to another could be increased, making an extended calving interval as an opportunity for dairy farmers.

3.4. Days Open

Days open (DO) is defined as the interval from calving to the day of conception, including the postpartum anestrous interval and service period. Days open is the most variable but determining component of calving interval. It has been influenced mainly by the length of time for the uterus to completely involute, resumption of normal ovarian cyclicity, the occurrence of silent ovulations, the accuracy of heat detection, management decisions on how soon to rebreed following parturition, fertility of a bull (semen) and efficiency and skill of inseminator. Days open affect lifetime production and generation interval (Ababu 2002).

Haile et al (2009b) studied Borena and their crosses with Holstein Friesian of five genotypes in Ethiopia and reported that the overall estimated mean values for days open were 127±7 days, 135±8 days, 142±8 days, and 134 ± 14 days for 50%, 62.5%, 75%, and 87.5%. The study of Sisay (2015) at Bako research center found a mean value of 91.46 ± 1.29 and 79.18 ± 2.00 from HF x Horro and Jersey x Horro crosses. The result indicated that Jersey x Horro had lower DO than HF x Horro crosses. This might have been the presence of genetic differences between HF and Jersey on the performance of DO.

From the reviewed reports, DO had varied from 76-243 days, which might depend on the crossbred type, blood level of each genotype, study location, and other environmental factors. The F_1 Jersey x Arsi had the shortest, whereas 75% HF x Borena second generation had the longest days open. In general, Jersey crosses are shorter DO compare to HF crosses. For instance, the F_1 Jersey x Arsi had 6.6 days shorter days open than F_1 HF x Arsi (Table 3).

Days open trait could be influenced or not influenced by non-genetic factors like season of calving, year of calving, and parity. The significant influence of year and parity on days open were reported by (Haile et al 2009b; Deriba 2012; Mengistu et al 2016). However, these authors have reported the non-significant influence of season on days open trait. Unlike these authors, Wassie et al (2015) found a significant effect of season on DO trait.

3.5. Number of Service per Conception

The number of services per conception (NSC) is the number of services (natural or artificial) required for successful conception. The number of inseminations required to produce a live calf is one of the most valuable parameters of reproductive efficiency, which mainly depends on the breeding system used. It is higher under uncontrolled natural breeding than hand mating and artificial insemination. Values of NSC greater than two should be regarded as poor (Mukasa Mugerewa 1989). The optimum recommended NSC for profitable dairy cows ranges from 1 to 1.7 (Evelyn 2001).

Regarding the genotype difference, review of crossbred animals on NSC in Ethiopia had variable results. The available on-station research results on NSC trait had in the range of 1.3-2.7, and the majority reports laid in the optimum recommendation by (Evelyn 2001). Gebeyehu et al (2005) found an average value of 1.54±0.1 from HF x Fogera crosses in northwestern Ethiopia. Both 1.69±0.07 and 1.75 ± 0.11 values were reported by Sisay (2015) from HF x Horro and Jersey x Horro at Bako research center. Another study by Wassie et al (2015) found relatively lower NSC (1.32±0.06 and 1.39±0.05) from Friesian x Arsi and Friesian x Borena at Agarfa agricultural training college. Kefena et al (2006a) found an overall average value of 1.52 from F_1 crosses, 1.54 from $F_{2,}$ and 1.41 from 75% crosses. However, Haile et al (2009b) reported higher values (2.2±0.10, 2.7±0.18, 2.2±0.17 and 1.7±0.11) from 50%, 62.5%, 75%, and 87.5% HF x Borena crosses from two research center data (Holetta and Debrezeyte).

On-farm study reports on NSC had shown optimum values. For example, Alemshet (2014) found 1.67 ± 0.04 and 1.63 ± 0.06 from retrospective data and survey monitor around Adigrate and 1.58 ± 0.07 had reported by Aregawi (2013) in eastern Tigrey from the on-farm survey of HF crosses.

Table 3 Days Open and Number of Service per Conception of crossbred dairy cows with different genotypes in Ethiopia.

Genotype	Reproductive traits		Sources
	DO (days)	NSC	
50% Jersey x Arsi (F_1)	76.3 ± 10.3	1.8 ± 0.1	Negussie et al (1998)
50% Jersey crosses (F_1)	162.75 ± 4	1.59 ± 4	Kefena et al (2006a)
50% Jersey crosses (F_2)	183 ± 2	1.68 ± 4	Kefena et al (2006a)
50% HF x Arsi (F1)	82.9 ± 12.3	2.0 ± 0.1	Negussie et al (1998)
50% HF x Zebu (F1)	120.8 ± 10.8	2.0 ± 0.2	Negussie et al (1998)
50% HF x Borena (F_1)	180.82 ± 6.03	1.64 ± 0.04	Getahun et al (2019)
50% HF x Fogera (F_1)	-	1.54 ± 0.1	Gebeyehu et al (2005)
50% HF crosses (F_1)	173.19 ± 5	1.46 ± 6	Kefena et al (2006a)
50% HF crosses (F_2)	173.5 ± 2	1.4 ± 4	Kefena et al (2006a)
50% HF x Borena (F_2)	222.67 ± 13.48	1.79 ± 0.09	Getahun et al (2019)
50% HF x Borena (F_3)	192.06 ± 17.64	1.84 ± 0.11	Getahun et al (2019)
75% HF crosses	169.17 ± 3	1.59 ± 5	Kefena et al (2006a)
75% Jersey crosses	-	1.23 ± 2	Kefena et al (2006a)
75% HF x Borena (F_g)	243.03 ± 14.39	1.97 ± 0.09	Getahun et al (2019)
75% HF x Borena (S_g)	108.55 ± 33.45	1.33 ± 0.19	Getahun et al (2019)
Crossbred	218.5	2.2	Emebet and Zeleke, (2007)
HF x Borena	134.84 ± 3.51	1.36 ± 0.03	Mengistu et al (2016)

HF = Holstien Friesian; $F_{1,}$ F_2 and F_3 = first, second and third filial generations for 50% genetic groups only; Fg = first generation for 75% genetic groups; S_g = second generation for 75% genetic groups

4. Final considerations

Many literature results in Ethiopia agreed, crossbred dairy cows produced better milk yield and reproductive performances than indigenous breeds because of the advantage of heterosis. However, their performance had lower than pure exotic parents. Most crossbred dairy cows' trait performances were influenced by year, season, and lactation numbers. In the long-term experiment on station condition, 50% F_1 crossbred genotypes were relatively performed well and indexed in milk production and reproductive traits. The second and third generations in all genotypes were poor in both milk yield and reproductive performances due to heterosis reduction. The 75% of first generations were higher milk producers than all other genotypes. Therefore, 50% F_1 and 75% first-generation crosses as dairy cows were the best options to the producers under the current dairy production conditions in Ethiopia, as extreme performance differences were not seen as at on-station and on-farm evaluated crossbred dairy cows. For reproductive performance, 50% F1 Jersey crosses were ideal genotype. Regarding both productive and reproductive performances, index selection should be applied by including all economic important traits.

Conflict of Interest

The author declare no conflicts of interest.

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