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Analysis of the Non-genetic Factors Influencing the Performance of High-grade and *Inter se* Mated Crossbred Dairy Cows at Holetta Dairy Research Farm, Ethiopia

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ABSTRACT

Background: The effect of non-genetic factors including feeding, management, climate, calving year, season and others on animal production improvement has attracted considerable attention in recent years. In addition to improving animal genetics, the importance of optimum environmental conditions in enhancing animal production is recognized.

Methods: Data collected from 2008 to 2018 on 2036 records from crossbreeding dairy cattle herd at Holeta Agricultural Research Center were analyzed to evaluate the genetic and non-genetic environmental effect on lactation milk yield (LMY), lactation length (LL) and calving interval (CI). The fixed effect used in the data analysis were breed group, parity, years group of calving and seasons of calving. GLM procedure of SAS was used to analyze the data.

Result: Results of data analysis indicated that breed group and year group of calving had a significant (P<0.05) effect on LMY, LL and CI. Parity significantly (P<0.05) affected LMY and CI but had no significant effects on LL. While, season of calving had no significant influence on all traits. Least square mean LMY was significantly (p<0.05) highest (3191 kg) for 75% first generation breed group and significantly (P<0.05) lowest for pure Ethiopian Borena breed (124 kg LMY). Mean LL was significantly (p<0.05) highest (354 days) for 75% first generation breed group and significantly (P<0.05) lowest for pure Ethiopian Borena breed (178 days). Least square mean CI was significantly (p<0.05) longest (477 days) for 75% first generation breed group and significantly (P<0.05) shortest (422 days) for 75% *inter se* mated breed group. Among 75% crosses, the 75% *inter se* mated breed group had lower LMY (2553 kg) and shorter CI (422 days) compared to 75% first generation breed group. The decline in LMY and CI for 75% *inter se* mated breed group by 637 kg (25%) and 54 days (13%), respectively compared to 75% first generation, which can be attributed to recombination effect.

Key words: Crossbred dairy cow, *Inter se* mated breed, Lactation milk yield.

INTRODUCTION

The dairy sector has a significant contribution to the national economy and the livelihood of the farming community of Ethiopia. However, the productivity of animals is very low. The average milk yield per lactation of the indigenous cows ranges from 494 to 850 kg under research station management conditions (EARO, 1999). Genetic improvement of the indigenous cattle through crossbreeding with exotic dairy cattle has been proposed as quick way of increasing milk production. Such crossbreeding in Ethiopia has been widely used as a method to combine the high milk yield of *Bos taurus* breeds with the adaptability of local breeds to animal diseases, low quality feed and poor management. The use of crossbreds for milk production in Ethiopia was based on earlier recommendations by Institute of Agricultural Research (IAR, 1982; Beyene, 1992). After this work, different studies have been done on evaluation of the performance of different crossbred dairy cattle at Holeta research center. However, information on performance of high grade and their *inter se* mated crossbred dairy cattle is lacking. Thus having, information on performance and factors affecting the performance of high-grade crossbred dairy cattle is vital for decision making on the continuation of the existing synthetic dairy cattle breed development in the study area. The aim of this study was to determine the non-genetic factors that influence the performance of high grade and *inter se* mated crossbred dairy cattle.

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MATERIALS AND METHODS

Description of the study area

This research was conducted at Holeta Agricultural Research Center (HARC). Geographically Holeta is located in the central highland of Ethiopia at 29 km west of Addis

Ababa (9° 00′ N latitude and 38° 30′ E longitude) with an altitude of 2400 meter above sea level. The average annual rainfall is 1100 mm and average annual temperature is 15°C with minimum 6°C and maximum 24°C, respectively. The average monthly relative humidity is 60% (Getahun *et al.* 2020).

Data source and data collection

Data for the study was obtained from crossbreeding program on synthetic cattle breed development in Holetta research center. The breed groups involved in this study were the indigenous breed, 50%F_1 (HF*Borena), 75% first generation [HF *(HF* Borena)] and 75% *inter se* mated {[HF *(HF* Borena)] * [HF *(HF* Borena)]}. Data collected on 716 LMY, 716 LL and 604 records on CI was used for this study. Individual records were collected for each cow and each calving. These include breed group, cow ID number, sire of cow, dam of cow, date of calving, date of dry-off and total lactation milk yield. LMY was computed as sum of daily milk yield (kg) from date of calving until dry-off date. Calving interval (days) for each lactation was computed as the difference between previous lactation calving date and next calving data. Lactation length (days) was computed as difference between date of start of milking and dry-off date.

A number of factors were identified in the preliminary screening of the data that had a bearing on the techniques used. Small number of observations for indigenous breed on LMY and non-overlapping years of calving between indigenous breed and the various crossbred cows. There was also some deviant observation presented in some of the breed groups, for example very short or long lactations. In the main analysis, these records with lactation length <100 or greater than 1000 days were deleted from the study in order to avoid possible aberrant results.

Animal management

Standard regular conditions of feeding and management practices are adopted for all animals. Natural grazing, hay and concentrate supplement constitute the major feed supply. Management systems like feeding and health in the herd can fluctuate from time to time depending on availability of feed and inputs. Getahun *et al.* (2020) extensively discussed the cow and calves feeding and management systems in the farm.

Breeding program

The breeding program in this herd is based on development of synthetic dairy cattle breed at 75% HF blood (25% of Borena and 75% of HF blood), by *inter se* mating of ¾ HF and ¼ indigenous breed (females Borena) with semen of 75% HF and 25% indigenous breed (males Borena) every generation. In this program the pure indigenous breed dams were mated with pure HF semen to produce the 50%F1 crosses, the 50% F_1 females is then back crossed with pure HF bull semen to produce the 75% first generation crosses. The 75% first generation females mated with 75% first generation males to produce 75% *inter se* mated animals. In this program, selected 75% first generation males are always mated with females of 75% first and subsequent generations. More about breeding program and source of sire semen or dam were discussed by (Getahun *et al.,* 2020).

Statistical analysis

Data collected from 2008 to 2018, 716 records on LMY, 716 records on LL and 604 records on CI were analyzed using General Liner Model (GLM of SAS, 2004). The least square analysis of variance was used to determine environmental and genetic or breed effects on LMY, LL and CI. The class variables used in the GLM model were breed group (4), parity (5), season of calving (2) and year group of calving (3). Year of calving ranged from 2008 to 2018 was grouped into three-year groups. These, year group one from 2008 to 2011, year group two from 2012 to 2015 and group three from 2016 to 2018. This grouping was based on similarity of significance difference of lactation milk yield during preliminary analysis. For evaluation of the effect of seasons on LMY, LL and CI, the months of calving were grouped into 2 seasons, dry season from October-February, wet season from March to September based on rainfall distribution of the study area. The interaction effects among fixed factors were not significant and excluded from the model of analysis.

The statistical model for analyzing LMY, LL and CI are:

$$y_{ijklm} = M + P_i + S_j + Y_k + B_l + e_{ijklm}$$

Where,

y_{ijklm} =m^{th} record of individual cows in lactation i, in season j, year groups k of breed group l.

M = Overall mean.

P_i = The effect due to the i^{th} lactation (i = 1, 2, 3, 4, 5 and above)

S_j = The effect due to j^{th} season of calving (1 and 2).

Y_k = The effect due to the k^{th} year group of calving (k = 1, 2, 3).

B_l = The effect due to the l^{th} breed group (l = pure Borena, 50% F_1, 75% first generation, 75% *inter se* mated).

e_{ijklm} = Random residual effect.

RESULTS AND DISCUSSION

Least square mean LMY, LL and CI for breed group and non-genetic factors are presented in Table 1.

Parity

Parity was significant influence on lactation milk yield ($P<0.05$). Lactation milk yield increased from first parity to fourth parity and decline then after. Haile *et al.* (2009a) reported similar trends for LMY in HF with indigenous crossbred cattle in Ethiopia. Mackinnon *et al* (1996) reported a decrease in milk yield and lactation length after the third parity on crosses of indigenous cows with Ayrshire, Brown Swiss and Sahiwal in Kenya. Martinez *et al* (1988) also reported that age difference, *i.e.* difference of parity, is one of the most important non-genetic sources of variation in milk yield. However, there was no significant difference in lactation length across parities. Calving interval was significantly decreased from first lactation to third lactation.

The decrease in CI between the first and subsequent lactations is in agreement with earlier studies by (Kifaro, 1984; Agyemang and Nkhonjera, 1986). The prolonged CI for cows in the first parity has been reported to be physiologically necessary to allow animals to replenish their fat reserves depleted during lactation and this allows them to put on weight prior to the next calving (million *et al.,* 2010).

Season of calving

There is no significance difference among seasons of calving on LMY, LL and CI (Table 1). This might be attributed to the uniform feeding system practiced by research center across seasons. Melaku (1994) did not find any effect of season on milk production traits in HF dairy herd at Holetta. The present result is also in agreement with the finding of several studies conducted in Ethiopia (Demeke *et al.,* 2004; Haile *et al.,* 2009a; Kefena *et al.,* 2006; Kefale *et al.,* 2020) who reported non-significance effect of seasons of calving. The non-significant effect of season of calving on CI in the present study indicated that the similarity in management across seasons. This finding is in agreement with report by (Singh and Rout, 1980; Mekonnen and Goshu, 1987; Sharma *et al.,* 1988; Enyew, 1992; Hirooka and Bhutyan, 1995). However, significant effect of season of calving was observed in previous studies conducted by Mekonnen and Goshu (1987) and Alemu *et al* (1988) on Borena cattle at Abarnosa ranch and, Asheber (1992) and Addisu (1999) on Fogera cattle. These different results on effect of season of calving on calving interval is attributed to different in feed availability and feeding system, breed and locations across herds.

Year group of calving

The estimated least square mean LMY, LL and CI for year group of calving are presented in Table 1. Lactation milk yield increased from year group 1 to year group 2 (from 2008-2011 to 2012-2015) and decreased thereafter 2016 to 2018. Cows calved during the year group 1 had provided higher lactation milk yield compared to other groups but lactation length was decreased from year group 1 to year group 3. These different results on effect of year group of calving on LMY and LL might be due to difference in feeding and other husbandry (management) provided to the animal. Although there was no consistent trend, estimated least square mean CI was highest for cows that calved during the year group 3 and lowest for year group 2. This inconsistent trend in CI across year groups might be attributed to changes in level of management such as changes in feed and feeding systems across years. Poor heat detection and incorrect time of insemination increase postpartum anestrus interval and days-open which in turn influence calving interval. Year effect on CI in the tropics has been reported to be indirect due to dynamic climatic changes which are frequently associated with disease pattern and changes in management by farm (Mulangila, 1997).

The progressive decrease in LMY and LL but increase in CI from year group 2 to year group 3 (Table 1) could be a sign of deterioration in management of the farm. The significant effect of years on CI in this study was in agreement with Million and Tadelle (2003), Million *et al* (2006), Gebeyehu *et al* (2007) and Haile *et al* (2009b) but inconsistent with the finding of Hunde *et al* (2015) on pure Jersey in Ethiopia. This inconsistency might be due to management and breed difference among the herds.

Breed effect

Least square mean LMY, LL and CI were increased as proportion of Holstein Friesian blood increased (from pure Ethiopian Borena to 75% (Table 1). The 75% first-generation crossbred cows produced significantly higher LMY, longer LL and longer CI compared to other breed groups. The Ethiopian Borena cows produced significantly the lowest LMY and had lowest LL. Among 75% crosses, mean LMY

Table 1: Least square mean (Mean +SE) on LMY, LL and CI.

Effect	No. of observations	LMY (kg)	LL (days)	No. of obser.	CI (days)
Breed group					
1/2 HF*1/2Borena	412	2264 ± 41.2^{C}	312 ± 3.16^{C}	309	425 ± 6.21^{C}
3/4 HF*1/4Borena (first generation)	258	3191 ± 74.4^{A}	354 ± 4.42^{A}	149	477 ± 10.5^{A}
$(3/4\ HF*1/4Borena)^{2}$ (*inter se* mated breed)	41	2553 ± 146^{BC}	319 ± 16^{BC}	15	422 ± 34^{C}
Pure Ethiopian Borena	5	124 ± 10.8^{D}	178 ± 4.28^{D}	131	468 ± 9.64^{BA}
Parity					
1	235	1850 ± 71^{C}	290 ± 5.18^{A}	197	474 ± 8.99^{A}
2	183	2101 ± 77.7^{AB}	299 ± 5.81^{A}	152	459 ± 10.2^{AC}
3	129	1986 ± 91.7^{AC}	287 ± 5.84^{A}	103	428 ± 9.36^{C}
4	81	2172 ± 124^{A}	291 ± 8.01^{A}	152	431 ± 8.59^{C}
5	88	2055 ± 114^{AC}	286 ± 8.32^{A}		
Year group of calving					
Year group 1 (2008-2011)	24	2067 ± 189^{AB}	308 ± 13.2^{A}	13	453 ± 25.7^{AB}
Year group 2 (2012-2015)	112	2370 ± 107^{A}	299 ± 6.51^{BA}	100	426 ± 9.26^{B}
Year group 3 (2016-2018)	580	1662 ± 44^{B}	265 ± 3.57^{C}	491	465 ± 5.51^{A}

^{ABCD} Means within fixed effects without common superscript differ at $p<0.05$.

was significantly decreased by 25% for 75% *inter se* mating breed group compared to 75% first generation breed group. While LL was declined by 34 days (10%) for 75% *inter se* mated breed group compared to 75% first-generation crosses. Similar to present study Million and Tadelle (2003), Haile *et al.* (2009a) and Kefale *et al*. (2020 reported higher LMY for 75% first generation breed group compared to 50% and 62.5% genetic groups. The present result of breed effect on lactation milk yield is similar with finding of crossbreeding experiment Million (2001) between HF and indigenous breed, where high-grade cows produced the highest LMY than the other breed groups. Hirooka and Bhutyan (1995) also reported high milk yield by exotic breed in tropics are achieved when animals were well fed and managed indicating that the genetic potential of genotype depends on the level of management. Given the tropical environment of the study area, the better milk production performance of 75% crossbred over local and F_1 crosses in this herd when management levels were good and supportive of this conclusion. The declined in lactation milk yield and lactation length for *inter se* mated breed is attributed to recombination loss (interaction of gene at different loci originating from parents). Mackinnon *et al.* (1996) and Million *et al.* (2004) also observed declined in lactation milk yield on *inter se* mated breed groups in crossbred dairy herds.

Mean calving interval was significantly ($P< 0.05$) longer for 75% first-generation crosses and shortest for 75% *inter se* mated breed group and 50% F_1 crosses. Among 75% crosses, CI was decreased by 54 days or (13%) for 75% *inter se* mated breed compared to 75% first generation breed group. The effect of breed on calving interval estimated in this study is similar with results of Million et al. (2004) who reported longer calving interval for high-grade Holstein Friesian crosses (> 75%) and shorter interval for F_1 and the Arsi breeds. However, it is longer than the results reported by Pedron *et al.* (1989) who found 392-407 days CI from different herds and 421 days obtained by Moges and Baars (1998) in Holstein Frisian breed in Ethiopia. The longer calving interval for 75% first generation crosses may be related to environmental effect such as level of management, which negatively affects postpartum estrus interval and days to conception. Good reproductive management together with appropriate feeding system is needed for better performance. Mean calving interval in the present study is above the ideal interval of 365 days expected. This longer CI may be attributed to environmental factors, mismanagement practices like poor nutrition or failure to detect heat on time (Msanga *et al.,* 1999). The decreased in calving interval for *inter se* mated breed might be attributed to recombination effect (interaction of gene at different loci originating from parents). Million *et al (*2006) also reported similar decrease in calving interval by 41 days for 75% *inter se* mated breed compared to 75% first generation breed in crossbreeding experiment in Ethiopia. One limitation, which observed in this study was the small number of observation found in the breed group (5 observation on pure Ethiopian Borena) and in the year group (24 observation on the year 2008-2011). Their values might be difficult to compare from the respective breed or year group in this study, which lead to some biasness of the results.

CONCLUSION

Least square mean Lactation milk yield and calving intervals were significantly affected by breed, year of calving and parity while lactation length was affected by breed and year of calving. Lactation milk yield increased as proportion of HF blood increased. The 75% first generation cross had higher lactation milk yield, lactation length and longer calving interval compared to other breed groups. Mean lactation milk yield was significantly decreased by 25% while lactation length was declined by 34 days (10%) for 75% *inter se* mating breed group compared to 75% first-generation crosses which might be attributed to recombination losses (interaction of gene at different loci originating from parents). Up grading to 75% HF blood level can be worthwhile though there is a need to minimize the declined in LMY observed for 75% *inter se* mated breed group. Intensive selection among pure Ethiopian Borena breed and crossbred animals and improving the existing level of management are crucial for sustainability of breed improvement effort at the research center.

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