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Full Length Research Paper

Genetic analyses of first lactation traits of Boran and their crosses with Holstein and Jersey in central highlands of Ethiopia

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Data obtained from Holeta Agricultural Research Center in Ethiopia were analyzed to compare the Boran cattle and the crossbreds and estimate genetic and crossbreeding parameters for first lactation traits. First lactation traits studied were first lactation total milk yield (FLMY), first lactation length (FLL), milk yield per day to first lactation (FLDMY), first 305 days milk yield (MY305) and adjusted first lactation 305 days milk yield (AFL305DMY). The effect of genetic group was significant (p<0.05). Boran cattle were inferior to any of the crosses. There was no significant (p>0.05) difference between HF x Bo and HF x HFBo or J x Bo and J x JBo and thus exotic inheritance beyond 50% showed no improvement in first lactation traits. The heritability estimates were medium (0.21+03) for FLL to high (0.39+0.40) for FLDMY. The breed additive difference for HF or Jersey was positive and significant (p<0.05) for all traits. The breed additive for HF were estimated as 2713.89 ± 406.60 kg, 110.27 ± 61.23 days, 6.09 ± 0.88 kg, 1169.43 ± 336.87 kg and 1432.86 ± 263.10 kg, whereas breed additive for Jersey were 2269.96 ± 486.05 kg, 59.37 ± 73.20 days, 5.25 ± 1.05 kg, 1207.56 ± 431.46 kg and 1413.28 ± 314.51 kg for FLMY, FLL, FLDMY, M305 and AFL305DMY, respectively. The individual heterosis was significant (p<0.05) for HF x Boran crosses, but not (p>0.05) for Jersey x Boran crosses except FLDMY and AFL305DMY. Crossbreeding improved first lactation traits three to four folds. Thus, crossbreeding with management interventions could be recommended to improve milk production.

Key words: Crossbreeding, genetic parameters, milk yield, non-genetic factors.

INTRODUCTION

Ethiopia possesses huge cattle genetic resources. However, the country is deficit in milk. The per capita consumption of milk in Ethiopia is about 19 kg/year, which is much lower than the world's per capita average of about 100 kg/year (Azage and Alemu, 1997). The estimated average lactation milk yield per cow for the indigenous cows ranged from 494 to 850 kg under optimum management condition (EARO, 1999). The milk production of Boran cattle, based on few studies ranged from 500 to 1000 kg per lactation with lactation length of less than 200 days (IAR, 1976; Demeke et al., 2004; Haile et al., 2009). Thus, the milk produced from the indigenous cattle was not sufficient to meet the ever increasing demand for milk. Consequently, Ethiopia is importing milk, and import dependence has showed a steady progress, worsening during drought periods. The imports grew rapidly at 24.18% per year and it is estimated that imported milk powder accounted for 23% of Addis Ababa market (Getachew and Gashaw, 2001).

The agricultural policy of Ethiopia, among others entails supplying hygienic and fresh milk to the consumers and ensuring import substitution. This has necessitated formulating strategies for increasing domestic milk yield and supply. Milk production can be increased by genetic improvement as well as improving management especially

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Table 1. Number of records used in the analyses.

Trait[a]	Genetic group			Total
	Friesian cross	Jersey cross	Boran	
FLMY	368	232	207	806
FLL	368	23)	207	807
FLDMY	368	232	207	807
MY305	283	182	70	535
AFL305DMY	368	232	207	807

[a]FLMY, First lactation milk yield; FLL, first lactation length; FLDMY, first lactation dai ly milk yield; MY305, 305 days milk yield; AFL305DMY, adjusted first lactation daily milk yield.

feeding and diseases (Rege, 1991; Getachew and Gashaw, 2001). In order to hasten the genetic potential for milk production, the crossbreeding was adopted in Ethiopia during the 1950's. Comparing the performance of crossbreds and indigenous cattle, and evaluating the genetic and cross breeding parameters is an essential pre-requisite for a sound and sustainable cross breeding program. Few studies have assessed milk production performance of indigenous and crossbred cows by considering life time milk production (Demeke et al., 2004; Haile, et al., 2009; Kefena et al., 2011). Besides, there is limited information on first lactation traits in Ethiopia. The information on crossbreeding is much more relevant today than ever, where Ethiopia has launched massive crossbreeding activities in different agro-ecologies to improve milk production. Therefore, the objective of this study was to evaluate first lactation performance of Holstein or Jersey crosses with Boran and to estimate genetic and crossbreeding parameters.

MATERIALS AND METHODS

Source of data

Data for this study were obtained from Holeta Agricultural Research Center in Ethiopia from the year 1980 to 2006 (Table 1).

Description of the Holeta research center

Holeta Agricultural Research Center is located 35 km west of Addis Ababa, the capital city of Ethiopia, at 38.5°E longitude and 9.8°S latitude, and with elevation of 2400 m above sea level. The average annual rainfall of the region is about 1200 mm, most of it occurring between July and October. The dry season lasts from October to February followed by light showers between March and May and June to September, main rainy season. The research center is situated in the central highlands of Ethiopia. The average monthly temperature is 17°C with a minimum of 10°C and a maximum of 26°C and the average monthly relative humidity is about 60%.

Animals and management

Free grazing and concentrate supplementation were feeding procedures used on the farm. The animals were grazing on natural pasture for about 8 h during daytime and housed and offered hay prepared from natural pasture at night. There was a differential feeding practice for different classes of animals. The lactating cows were supplemented with approximately 3 to 4 kg of concentrate at each milking. Occasionally, during the long-dry period and based on the condition of the animals, dry and young stocks were supplemented with an unspecified amount of concentrate. The concentrate was composed of 30% wheat bran, 32% wheat middling, 37% noug seed cake (*Guzeta abysinica*) and 1% salt. All animals had free access to clean water. The animals were provided veterinary aid, prophylactic and sanitary measures as a routine practices.

Classification of major effects

The major effects fitted were genotype (seven classes: Boran; HF x Boran, HF x HFBO; HFBO x HFBO; J x Boran; J x JBO; JBO x JBO); calving period of three years interval (nine classes: 1980 to 1982; 1983 to 1985; 1986 to 1988; 1989 to 1991; 1992 to 1994; 1995 to 1997; 1998 to 2000; 2001 to 2003; 2004 to 2006) which was grouped consistent to trends in management) and calving season, grouped into three classes, based on the pattern of annual rainfall distribution (October to February: dry period; March to May: light showers and June to September: main rainy season). A fixed effect model was fitted as presented in the following model: $Y_{ijkl} = \mu + G_i + S_j + P_k + e_{ijkl}$, where Y_{ijkl} is first lactation traits, μ is the overall mean, G_i, is the fixed effect of *ith* genetic group; S_j is the fixed effect of *jth* season of calving; P_k is the fixed effect *kth* period of calving and e_{ijkl} is error term attributed to factors not included in the model.

Data management and cleaning

Each lactation record was considered normal if a cow had produced milk for at least 60 days and terminated with registered voluntary drying-off. The truncation point of 60 days was based on the recommendation of Kiwuwa et al. (1983) for the indigenous Ethiopian cattle and their crosses. In addition, any record with lactation length of more than 1000 days was also excluded from the data analyses. In this study, the lactation lengths of between 60 and 1000 days were considered sufficient to include all usable records of the Boran (this breed often has a short lactation length because of milk let down problems), and crossbred cows milked longer (because of reproductive problems).

Statistical analysis

Least squares analysis

Traits included were first lactation total milk yield (FLMY), first lactation length (FLL), milk yield per day for first lactation (FLDMY), first 305 days milk yield which is the lactation records with and over 305 days taken at 305 days yield (MY305), and adjusted first lactation 305 days milk yield which included all first lactation milk yield less than 305 days and adjusted for 305 days using linear relationships (AFL305DMY). To study the effects of genetic and non-genetic factors and overcome the problem of non-orthogonality of the data due to unequal and disproportionate sub-classes, least squares analysis (SAS, 2002) was employed. Two-way interaction effects were fitted in the model and retained in the final model when found significant (p<0.05). The interaction effects were not presented in this paper. Selected contrast was performed within each fixed effect to test for significance difference between least-

Table 2. Genetic group, season and period wise least squares means and standard errors of first lactation traits for Boran and the crosses.

Effect	First lactation trait ^{a}				
	FLMY	**FLL**	**FLDMY**	**MY305**	**AFL305DMY**
Overall	1662.10 ± 124.24	349.01 ± 18.70	5.20 ± 0.27	1495.69 ± 114.17	1522.01 ± 80.29
N	806	806	806	535	806
Genetic ^{b}	**	**	*	**	*
Boran (Bo)	674.79 ± 53.71^{a}	237.43 ± 8.08^{a}	1.47 ± 0.11^{a}	683.53 ± 63.04^{a}	447.43 ± 34.71^{a}
HF x Bo	2119.04 ± 58.55e	360.43 ± 8.81^{c}	6.04 ± 0.12e	1968.51 ± 51.51e	1855.25 ± 37.84e
J x Bo	1662.96 ± 77.42^{cd}	328.04 ± 11.65^{b}	5.01 ± 0.16^{cd}	1490.55 ± 63.68^{c}	1466.86 ± 50.03^{cd}
HFBoxHFBo	1533.92 ± 70.11^{c}	342.14 ± 10.55^{bc}	4.62 ± 0.15^{c}	1486.41 ± 65.34^{c}	1417.22 ± 45.31^{c}
JBo x JBo	1230.31 ± 87.73^{b}	318.85 ± 13.20^{b}	4.10 ± 0.19^{b}	1279.37 ± 85.10^{b}	1215.72 ± 56.70^{b}
HFx HFBo	2216.14 ± 77.83e	370.51 ± 11.71^{c}	6.16 ± 0.16e	1879.16 ± 60.21e	1780.16 ± 50.30e
J x JBo	1805.27 ± 85.13^{d}	334.67 ± 12.81^{d}	5.42 ± 0.18^{d}	1580.19 ± 70.99^{c}	1575.20 ± 55.02^{d}
Season	NS	NS	NS	NS	NS
Light rain	1540.25 ± 43.98	325.24 ± 6.62	4.63 ± 0.09	1438.70 ± 40.01	1373.92 ± 28.43
Heavy rain	1561.83 ± 52.07	324.88 ± 7.83	4.74 ± 0.11	1478.32 ± 44.96	1403.88 ± 33.65
Dry season	1587.54 ± 45.74	332.20 ± 6.88	4.70 ± 0.09	1483.43 ± 42.65	1404.13 ± 29.56
Period	***	**	***	**	**
1980-82	1671.49 ± 110.93^{b}	348.82 ± 16.69^{ab}	4.94 ± 0.24^{cd}	1536.52 ± 93.67^{bd}	1476.09 ± 71.69^{bc}
1983-85	1336.97 ± 135.01^{a}	319.65 ± 20.32^{acd}	4.40 ± 0.29^{bd}	1283.02 ± 131.89^{ab}	1312.80 ± 87.26^{ab}
1986-88	1758.02 ± 101.60^{bc}	337.53 ± 15.29^{b}	5.11 ± 0.22^{d}	1683.92 ± 92.49^{d}	1550.84 ± 65.66^{c}
1989-91	1279.74 ± 89.54^{a}	331.13 ± 13.47^{c}	3.84 ± 0.19^{a}	1195.18 ± 74.83^{ac}	1152.07 ± 57.87^{a}
1992-94	1374.63 ± 73.08^{a}	346.50 ± 11.00^{c}	3.93 ± 0.15^{a}	1182.76 ± 58.59^{a}	1147.18 ± 47.23^{a}
1995-97	1983.34 ± 72.84^{c}	388.75 ± 10.96^{bd}	5.03 ± 0.15^{d}	1598.80 ± 61.22^{d}	1487.22 ± 47.07^{c}
1998-00	1767.06 ± 62.16^{b}	318.96 ± 9.35^{b}	5.34 ± 0.13^{d}	1673.67 ± 59.83^{d}	1579.07 ± 40.17^{c}
2001-03	1661.10 ± 55.05^{b}	300.69 ± 8.28^{b}	5.09 ± 0.11^{d}	1668.81 ± 51.01^{d}	1503.23 ± 35.58^{c}
2004-06	1236.49 ± 70.19^{a}	254.94 ± 10.56^{a}	4.54 ± 0.15^{bc}	1378.67 ± 75.17^{bc}	1337.29 ± 45.36^{b}

P<0.05; **P<0.01; ***P<0.001; least squares means with similar superscript indicate non significance; [a]FLMY, first lactation milk yield; FLL, first lactation length; FLDMY, first lactation daily milk yield; MY305, 305 days milk yield, AFL305DMY, adjusted first lactation daily milk yield. [b]Bo, Boran; HF, Friesian; J, Jersey; HF x Bo or J x Bo, first crosses ; HFBO x HFBO or JBO x JBO (Interse mating); HFBO x HF or JBO x J (75% exotic : 25% Boran).

squares means using Tukey-Kramer test.

Heritability, genetic and phenotypic correlations

Co-variances, genetic and phenotypic parameters (heritability, genetic and phenotypic correlations) were estimated by employing an animal model using the Derivative-Free Restricted Maximum Likelihood (DFREML) computer package of Meyer (1998). The fixed effects influencing the lactation traits were identified through the Generalized Linear Model (GLM) procedures of SAS (SAS, 2002) and included in the model. The (co)variance components and heritability were estimated using a univariate animal model which fitted direct additive effects (a) and residual variances as random effects and the pertinent fixed effects (Meyer, 1998). The heritability estimates were obtained as $h^2_a=\delta^2_a/\delta^2_p$ (the direct heritability), where, δ^2_a is direct additive variance and $\delta^2 p$ is phenotypic variance, which is the sum of all variance components. Genetic correlations were estimated using bi-variate animal model. The convergence criterion for the variance component estimates was 10^{-7} and a maximum of 900 iterations were carried out for the convergence. Multiple regression analysis (SAS, 2002) was used to estimate crossbreeding parameters. For the regression analysis, coefficients of expected breed content and heterozygosity in the cow were fitted as covariates to obtain estimates of the individual additive (giF or giJ), individual heterosis (hiBF or hiB) and maternal heterosis (hmBF or hmBJ) effects using similar procedures to those of Hirooka and Bhuttyan (1995), Kahi et al. (2000) and Haile et al. (2009).

RESULTS AND DISCUSSION

Genetic and non-genetic effects

Boran cattle were inferior to any of the crosses by three to four folds in terms of first lactation traits (Table 2). The present study was in agreement with a number of works considering life time milk yield (Demeke et al., 2004; Million et al., 2006; Kefena et al., 2006; Haile et al., 2009). The comparison among the crossbreds revealed that, F_1 (50% HF x 50% Boran or 50% Jersey x 50% Boran) were superior to F_2-*inters* (50% HF x 50% Boran

Table 3. Estimates of variance components and heritabilities (h^2 ± SE) for first lactation traits.

Variance estimate[b]	Lactation milk yield [a]				
	FLMY	MY305	FLL	FLDMY	AFL305DMY
V_a	2430.6	10463.0	21.5	0.29	4140.2
V_e	6461.7	16711.0	2087.9	0.44	8026.9
V_p	8892.2	27174.0	2109.4	0.73	12167.1
H^2	0.27± 0.04	0.38± 0.05	0.21±0.03	0.39±0.40	0.34±0.09

[a]FLMY, First lactation milk yield; FLL, first lactation length; FLDMY, first lactation daily milk yield; MY305, 305 days milk yield, AFL305DMY, adjusted first lactation daily milk yield. [b] V_a , Additive genetic variance; V_e, residual variance; V_p, phenotypic variance.

or 50% Jersey x 50% Boran). This may be ascribed to heterosis effects in the F_1 and expected reduction in heterotic effect in F_2 crossbreds. A number of works have shown that F_1 crosses between *Bos indicus* and *Bos taurus* out perform F_2-*intese* cross breed levels particularly under poor to average management condition (Haile-Mariam et al., 1993; Demeke et al., 2004; Kefena et al., 2006). It could be suggested that, for small farmers of Ethiopia, it might to be appropriate to use F_1 crosses through the continuous supply F_1 crosses with affordable price and credit arrangements. In some countries like Brazil, it was possible to organize production of F_1 cross bred animals on marginal lands (Madalena et al., 1990). The present study further showed that, milk production of the HF x Bo was higher than the J x Bo crosses. The mean performances as well as the ranking order of different generations of the HF x Boran and Jersey x Boran crosses for milk production traits are in agreement with results reviewed for crosses of these two dairy breeds with *B. indicus* cattle in the tropics (Cunningham and Syrstad, 1987; Tibbo et al., 1994; Demeke et al., 2004). There was no significant (p>0.05) difference between HF x Bo and HF x HFBo or J x Bo and J x JBo in any of first lactation traits, suggesting that exotic inheritance level greater than 50% were not superior to half-bred for first lactation traits. The grading of crossbreds in favor of exotic blood did not improve the performance of crossbred heifers which might be attributed to suboptimal management which did not meet the requirements of the graded genotype. It was also noted that, the performance of crosses in Ethiopia were lower as compared to the crosses in other part of the continent which has been used Sahiwal and *B. taraus* in a crossbreeding program. The possible reason could be poor management practice, harsh environmental condition, poor performance of Boran breed compared to other native tropical breeds. Syrstad (1988) argued that, the improvement of the indigenous cattle should be emphasized because ‘improved zebu’ was better than non-improved crossbreds in milk production. Therefore, a breeding policy that advocates selection of indigenous cattle to serve as a base population for crossing with exotic bull is suggested to utilize the benefit of breed complementarities and heterosis.

The effect of season did not show a significant (p>0.05) effect on milk production traits. A number of works reported the non-significant effect of season on milk production traits (Kiwuwa et al., 1983; Demeke et al., 2004; Kefena et al., 2006 and Haile et al., 2009). The non significant effect of season on milk production traits entails that; the influence of climatic conditions may be negligible under optimal feeding and management conditions. However, a number of works have shown a significant effect of season on milk yield (Mehta and Bhatnagar, 1986; Shrivastava and Khan, 1987) in Indian sub-continent. The study conducted on Karan Fries, Jersey x Tharparkar revealed that, the cows calving in October to December had higher 305 days milk yield, while those calving in April to June had a tendency to produce less milk compared to other seasons (Mehta and Bhatnagar, 1986) in India.

Effect of period was significant (p<0.01) on all milk production traits. The effect of period did not follow a clear cut trend. However, there was a general tendency that, cows that calved in the middle of periods (1989 to 1991) and (1992 to 1994) had shown lowest milk production compared to other periods. The variation in milk production performance over periods may not only be caused by inter-annual random change of the climatic factors, but may also include management changes over periods. Inter-annual variation in milk production for grazing dairy cows is a common phenomenon in tropical dairy production systems (Kiwuwa, et al., 1983; Thorpe et al., 1993; Rege et al., 1994; Demeke et al., 2004; Haile et al., 2009).

Genetic parameters

Heritability estimates

Estimates for variance components and heritability (h^2) for first lactation milk production traits are presented in Table 3. The heritabilities estimated for FLMY, FLL, FLDMY, MY305 and AFL305DMY were 0.27±0.04, 0.21±0.03, 0.39±0.40, 0.38±0.05 and 0.34±0.09, respect-

Table 4. Genetic (above diagonal) and phenotypic (below diagonal) correlations (se) for first lactation traits.

Lactation milk yield [a]	Lactation milk yield [a]				
	FLMY	**MY305**	**FLL**	**FLDMY**	**AFL305DMY**
FLMY	-	0.90 ± 0.11**	0.70 ± 0.15	0.81 ± 0.14**	0.60 ± 0.12**
MY305	0.80 ± 0.01**	-	0.70 ± 0.59	0.81 ± 0.15**	0.60 ± 0.11**
FLL	0.60 ± 0.20**	0.70 ± 0.14**	-	0.67 ± 0.39	0.67 ± 0.69
FLDMY	0.71 ± 0.05**	0.60 ± 0.06**	0.57 ± 1.86	-	0.57 ± 0.53
AFL305DMY	0.50 ± 0.02**	0.50 ± 0.08**	0.56 ± 0.36	0.51 ± 0.14**	-

[a] FLMY, First lactation milk yield; FLL, first lactation length; FLDMY, First Lactation Daily Milk Yield; MY305, 305 days milk yield, AFL305DMY, adjusted first lactation daily milk yield.

Table 5. Estimates of breed additive, individual heterosis and maternal heterosis for first lactation traits.

Genetic effect [b]	Lactation milk yield[a]				
	FLMY	**FLL**	**FLDMY**	**MY305**	**AFL305DMY**
GiHF	2713.89 ± 406.60***	110.27 ± 61.23*	6.09 ± 0.88***	1169.43 ± 336.87***	1432.86 ± 263.10***
HiHFBo	399.64 ± 217.19*	70.58 ± 32.71*	1.59 ± 0.47***	700.98 ± 188.71***	707.50 ± 140.54***
HmHFBo	-393.14 ± 156.36**	15.26 ± 23.54	-0.66 ± 0.34*	-134.34 ± 141.09	-94.56 ± 101.18
GiJ	2269.96 ± 486.05***	59.37 ± 73.20	5.25 ± 1.05***	1207.56 ± 431.46**	1413.28 ± 314.51***
HiJBo	178.90 ± 252.65	66.55 ± 38.05	1.05 ± 0.55*	208.30 ± 228.65	346.21 ± 163.48*
HmJBo	-358.47 ± 198.32	20.11 ± 29.86*	-0.50 ± 0.43	-114.30 ± 185.41	-101.24 ± 128.33

*P<0.05; **P<0.01; ***P<0.001. [a]FLMY, First lactation milk yield; FLL, first lactation length; FLDMY, first lactation daily milk yield; MY305, 305 days milk yield, AFL305DMY, adjusted first lactation daily milk yield. [b]GiHF, breed additive for Friesian; HiHFBo, Individual heterosis for HF x Boran; HmHFBo, maternal heterosis for HF x Boran ; GiJ, breed additive for Jersey; HiJBo, individual heterosis for Jersey x Boran; HmJBo, maternal heterosis Jersey x Boran.

tively. The estimates were more or less similar to the estimates reported by of a number of works (Singh and Gurnani, 2004; Nehra et al., 2005). The heritability estimates for first lactation milk production traits in Ethiopia are scanty. Mohammed (2003) in Ethiopia reported heritability value for FLMY and 305 days lactation at 0.14 and 0.20, respectively using an animal Model. Some researchers have observed that, estimates of heritability were higher for first lactation traits than later lactations (Meyer, 1984; Sigurdsson, 1993; Albuquerque et al., 1995). The moderate heritability value suggested that, sufficient additive genetic variation is required and thus the scope for genetic improvement through selection of indigenous and crossbred population to increase milk yield.

Genetic and phenotypic correlations

Genetic and phenotypic correlations are presented in Table 4. The genetic correlation ranged from 0.57 ± 0.53 between AFL305DMY and FLDMY to 0.90 ± 0.11 between FLMY and MY305, and the phenotypic correlation was lowest (0.50 ± 0.08) between MY305 and AFL305DMY, and was the highest (0.80 ± 0.01) between FLMY and MY305. The results of the present study are more or less in agreement with the reports in the tropics (Rege, 1991; Demeke et al., 2004; Haile et al., 2009). Genetic correlations were greater than the phenotypic correlations for most of the traits and these were in agreement with reports of many other works (Rege, 1991; Koots et al., 1994, Ahunu et al., 1997; Lobo et al., 2000). The high genetic correlation among first lactation traits is an indication that, the traits could be improved simultaneously in selection programs.

Cross breeding parameters

Breed additive, individual hetersosis and maternal heterosis for milk production traits is presented in Table 5. The breed additive difference for HF or Jersey was positive and significant (p<0.05) for all traits. The breed additive for HF was superior to the breed additive for Jersey crossed with Boran. The results of the present study are in general agreement with a number of works in tropics (Million and Tadelle, 2003; Million et al., 2004; Demeke et al., 2004; Haile et al., 2009). The breed additive contributions of the HF breed for milk production traits are generally higher than corresponding estimates reported for this breed elsewhere in the tropics (Sharma and Pirchner 1991; Thorpe et al., 1993; Mackinnon et al., 1996). The higher additive contribution in the present study and the previous cross breeding parameter estimates in Ethiopia might be a result of the lower milk production potential of the Boran cattle breed compared with other milking type of tropical indigenous cattle, such as the Sahiwal, commonly used in several other crossbreeding studies (Cunningham and Syrstad, 1987; Mackinnon et al., 1996; Kahi et al., 2000; Haile et al., 2009).

The individual heterosis was significant ($p<0.05$) for HF x Boran crosses, but individual heterosis was not significant ($p>0.05$) for Jersey x Boran crosses except FLDMY and AFL305DMY (Table 5). The individual heterosis in the present study for HF x Boran crosses was superior to Jersey x Boran crosses.

These estimates were within the range reported individual heterotic effects for milk production traits of other *B*. *taurus* x *B*. *indicus* crosses (Sharma and Pirchner, 1991; Thorpe et al., 1993; Rege et al., 1994; Million and Tadelle., 2003; Demeke et al., 2004; Haile et al., 2009). The maternal heterosis did not show a significant ($p>0.05$) effect on first lactation milk yield for HF x Boran crosses except FLMY and FLDMY and except FLL for Jersey x Boran crosses. The estimates on the maternal heterosis for HF x Boran crosses were -393.14 ± 156.36 kg, 15.26 ± 23.54 days, -0.66 ± 0.34 kg, -134.34 ± 141.09 kg and -94.56 ± 101.18 kg for FLMY, FLL, FLDMY, MY305 and AFL305DMY, respectively, whereas maternal hetersosis for Jersey x Boran were estimated as -358.47 ± 198.32 kg,20.11 ± 29.86 days, -0.50 ± 0.43 kg, -114.30 ± 185.41 kg and -101.24 ± 128.33 kg for FLMY, FLL, FLDMY, MY305 and AFL305DMY, respectively. The results of the present study is in general agreement to cross breeding parameter estimates in Ethiopia in related milk production traits (Demeke et al., 2004; Haile et al., 2009). The heterosis effect was found large in the present study which shows that the wider the genetic distance or phenotypic difference between parental breeds, the greater is the heterosis expressed (Kahi et al., 2000). The higher heterosis effect obtained in this study suggests the improvement in milk production through exploiting the additive and heterotic effect.

Conclusions

Boran cattle were consistently poor milk yielders and milk production was improved up to three folds by crossing of HF or Jersey breeds with Boran cattle. The HF x Boran crossbreds excelled Jersey x Boran crosses. Period of calving had shown a significant effect for most of the production traits; however season of birth was not significant. The genetic association that existed between milk production traits (except for some traits) was higher.

The heritability values for first lactation traits were also generally moderate to high. Therefore, there is a scope for selection and crossbreeding to improve milk production coupled with standardization of management. The breed additive differences between Boran and HF or Boran and Jersey for milk production traits were significant and positive. The individual heterosis was significant and positive in HF x Boran but significant and positive for some of first lactation traits in Jersey x Boran crosses. The superiority of direct additive of the Holstein or Jersey breed over Boran cattle for most lactation traits indicated that Holstein or Jersey could be used as exotic breed to improving these traits by crossing with native breeds.

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