Characterizing lactation curve of indigenous and crossbred cows

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Abstract

Initial and peak milk yield, days to peak milk yield and persistency index (PI) of indigenous and crossbred cows were determined to characterized their lactation curve. The study was based on existing data in the Bako Agricultural Research Center and Debre Zeit Research Station. The overall mean initial and peak milk yield, days to peak and PI were 5.5 ± 0.07 kg, 8.2 ± 0.17 kg, 44.0 ± 1.17 days and 86.2 ± 0.70 %, respectively. Crossbred cows had significantly ($p < 0.001$) higher initial and peak milk yield and longer days to peak than the indigenous breeds. PI, however, was significantly ($p < 0.05$) higher in Simmental crosses compared to the other sire breeds considered. Among the crossbreeds, the Jersey crosses had significantly the highest initial (7.1 ± 0.24 kg) and peak milk yield (9.9± 0.21 kg) while the Simmental crosses had the longest days to peak (49.4 ± 4.32) and the highest PI (91.4 ± 1.83%). The Horro, as a sire breed, had significantly ($p < 0.001$) higher initial (3.3 ± 0.25 kg) and peak milk yield (5.5 ± 0.25 kg) than the Boran, while as a dam breed, the Boran had significantly (at least $p < 0.01$) higher peak milk yield (8.1 ± 0.16 kg) and longer days to peak (46.6 ± 2.22 days) than the Horro. The Debre Zeit herd had significantly ($p < 0.01$) higher initial (5.1 ± 0.25 kg) and peak milk yield (7.8 ± 0.25 kg), shorter days to peak (33.2 ± 4.39 days) and higher PI (89.2 ± 1.75 %) than the Bako herd. Parity significantly affected ($p < 0.001$) initial and peak milk yield only. Initial and peak milk yield showed curvilinear trend with parity, both increased till fourth parity and then started to decline. Cows that calved during Gana, Arfasa, Bona and Birra had the highest initial and peak milk yield, longest days to peak and highest PI, respectively. Significantly (at least $p < 0.05$) highest initial (5.9 ± 0.35 kg) and peak milk yield (8.5 ± 0.32 kg) were observed for cows that calved in 1981 while the longest days to peak milk yield was recorded for cows that calved in 1991 (53.7 ± 8.09 days).

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Part of a thesis 'Gebregziabher Gebreyohannes 2001. Study on components of days open in relation to postpartum body weight dynamics and modelling lactation curve in zebu and crossbred cows. MSc. ThesisAlemaya University. 227P.'

Covariance analysis of these traits on calving weight showed that initial milk yield (b = 0.014 ± 9.48), peak milk yield (b = 0.02 ± 10.1), days to peak (b = -0.082 ± 0.03) and PI (b = 0.015 ± 0.01) were linearly ($p < 0.001$) related to calving weight. Similarly, days to peak yield (b = -2.26 ± 0.05) and PI (b = -0.54 ± 0.22) were linearly ($p < 0.001$) related to initial milk yield. Correlation analyses of initial and peak milk yield, lactation yield, lactation length and PI with calving weight indicated positive correlation (range r = 0.148 to 0.826; $p < 0.001$), while the correlation of days to peak with calving weight was negative (r = -0.229; $p < 0.001$). Besides, initial and peak yield, lactation length and lactation yield were positively correlated between each other. From this study it can be concluded that crossbreeding improved the traits studied. Genetic and non-genetic factors affected the traits, and calving weight had an important role to play in improving the traits considered in this study. Further more, the correlation among the traits could be used as a basis for selection purposes.

Keywords/phrases: lactation curve, persistency, initial milk yield, peak milk yield, days to peak

Introduction

Low genetic merit for milk production of the indigenous cattle breeds has been identified as a constraint to dairy development in Ethiopia (Alberro and Haile-Mariam, 1982). As a result crossbreeding indigenous cattle with exotic sire breeds have been tried to upgrade the Horro and Boran local breeds. This made considerable improvement in growth and milk production in the F_1 generation (Sendros *et al.*, 1987; Chernet *et al.*, 2000). However, genetic improvement without the improvement in the feeding and management may not enable the improved genotypes to express their genetic potential.

Feeding a dairy cow is uniquely different from other aspects of livestock feeding because of variations in milk yield response to different feeding levels with the advance in lactation. Milk production on a daily basis is rather curvilinear in response to individual variations in initial and peak milk yield, days to peak yield and persistency of lactation which are important in characterizing a lactation curve (Koley *et al.*, 1981; Yadav and Sharma, 1985).

Under normal conditions the animal starts secreting milk immediately after parturition and the daily milk yield increase rapidly to a maximum between days 35 and 50 of lactation (Haresign, 1979). Dairy cows in the tropics have been reported to peak in milk yield between the third and sixth week after calving (El-Amin and Osman, 1971) while cattle under intensive production system in the temperate region peak at about five to six weeks of lactation followed by a continuous decline in production (Madalena *et al.*, 1979). Initial milk yield determines the starting point of the lactation curve and it is responsible for lowering or raising the lactation curve (Batra, 1986). Variations in peak accounted for 83% of variance in total yield, as compared to the variations accounted to persistency, which is 12%. This dominance of peak over persistency was also apparent in the mean effects of treatments applied over the whole lactation and influences the total lactation performance (Broster and Thomas, 1981).

Persistency is a measure of the shape of the lactation curve and it is a dimension less quantity (Wood, 1969; Cobby and Le Du, 1978) that can only be used for comparisons of lactation. Under favorable conditions, unbred cows produce each month 94% of their yield during the preceding month. Low persistency could be either inherited or due to under feeding or exhaustion of body reserves or other unknown mechanisms that compensate for the higher solicitation of the mammary gland at peak yield (Chilliard, 1992). Low persistency coefficients are characteristics of poor lactation milk yields and often of short lactation duration.

Several studies (Madalena et al., 1979; Koley et al., 1981; Yadav and Sharma, 1985; Ibeawuchi, 1988; Gashaw et al., 1994; Mureja, 1994) have tried to determine initial and peak milk yield, days to peak and persistency and reported different values due to differences in genotypes, management, parity, nutrition, age and calving season. Hence, determining these traits for a particular genotype under a specific management will enable to understand the characteristics of that lactation curve for that particular genotype and management and enable efficient allocation of inputs to maximize return. The objective of this study was, therefore, to characterize the lactation curve of indigenous and crossbred cows and see the effects of genetic and non genetic factors on these traits.

Materials and Methods

The study was conducted based on existing data from Bako Agricultural Research Center of Oromia Agricultural Research Institute and Debre Zeit Research Station of the International Livestock Research Institute (ILRI). Details of the two centers climatic condition, livestock management, breeding and health care are indicated in previous works (Gemechu, 1992;

Gebregziabher and Mulugeta, 1996). Lactation data of pure Horro and Boran cows and their F_1 crosses with Jersey, Friesian and Simmental exotic sire breeds obtained from Bako Agricultural Research center and lactation data of pure Boran and their crosses with Friesian exotic sire breed were used for the study. Lactation records of 1313 cows (787 records from Bako and 526 records from Debre Zeit) were used for the analysis. The traits considered were initial milk yield (first day milk yield after colostrum period), peak daily milk yield (the maximum daily yield in the ascending phase of lactation), days to peak milk yield (interval from calving to date of peak yield) and persistency (the extent to which peak yield is maintained).

Persistency was measured using persistency index calculated by the application of the method of ratios as described by El-Amin and Osman (1971) and Ibeawuchi (1988). For the calculation of persistency index, each lactation curve was divided into four equal parts of ten weeks each after excluding the first five weeks that represented the initial rising phase of the lactation curve. The total ten week yield of each of the four periods was then calculated and the following ratios established $R_1 = X_2/X_1$, $R_2 = X_3/X_2$ and $R_3 = X_4/X_3$; where X_1, X_2, X_3 and X_4 were total milk production during the four periods. The R_1, R_2 and R_3 were then used to calculate the following weighting factors (W_1, W_2 and W_3); $W_1 = R_1/(R_1 + R_2 + R_3)$; $W_2 = R_2/(R_1 + R_2 + R_3)$; $W_3 = R_3/(R_1 + R_2 + R_3)$. Persistency index (PI) was then calculated as PI $= (W_1 * X_2/X_1 + W_2 * X_3/X_2 + W_3 * X_4/X_3) * 100$. For cows with extended lactation yield of greater than 315 days, the yield beyond this period was not considered in the calculation of persistency index since such persistency measure does not allow inclusion of very long (greater than 305 days) and short lactations (less than 305 days).

All traits were analyzed using the General Linear Model (GLM) of the Statistical Analysis System (SAS, 1999). The GLM included fixed effects of sire and dam breed, parity, calving season and year and location. Besides, calving weight and initial milk yield were considered as covariate when days to peak, peak milk yield and persistency index were analyzed. Five sire breeds (Jersey for Boran x Jersey and Horro x Jersey; Simmental for Boran x Simmental and Horro x Simmental; Friesian for Boran x Friesian and Horro x Friesian; Boran for pure Boran and Horro for pure Horro); two dam breeds (Boran as dam breed for pure Boran and Boran crosses with Friesian, Jersey and Simmental; Horro as a dam breed for pure Horro and Horro crosses with Friesian, Jersey and Simmental), six parities (one to six with the sixth parity including parities six and above pooled together); four calving season categories based on the centers meteorological data: *Gana* (main rainy season) from June to August, *Birra* (spring) from September to November, *Bona* (dry season) from December to February and *Arfasa* (beginning of the rainy season) from March to May; nineteen calving years (1980 to 1998) and two locations (Bako and Debre Zeit) were considered as a fixed effects.

Results

Mean squares and least square means of initial and peak milk yield, days to peak milk yield and PI are presented in Tables 1, 2 & 3. The overall mean initial and peak milk yield, days to peak milk yield and PI were 5.5 ± 0.07 kg,
8.2 ± 0.17 kg, 44.0 ± 1.17 days and 86.2 ± 0.70 %, respectively. Crossbred cows had significantly ($p < 0.001$) higher initial and peak milk yield and longer days to peak than the indigenous breeds. Simmental crosses had significant ($p < 0.05$) the highest (91.4 ± 1.83%) PI while the Boran (81.0 ± 3.60%; Table 3) the lowest PI compared to the other sire breeds. Among the crossbreeds, the Jersey crosses had the highest initial (7.1 ± 0.24 kg) and peak (9.9 ± 0.21 kg) milk yield compared to the Friesian and Simmental crosses. The number of days to peak was not significantly different among the crosses. PI, however, was significantly ($p < 0.05$) highest for Simmental crosses (91.4 ± 1.83 %) than the Friesian (86.6 ± 0.96%) crosses (Table 3). As a sire breed, the Horro had significantly ($p < 0.001$) higher initial and peak milk yield than the Boran. While as a dam breed, Boran cows had significantly ($p < 0.001$) higher peak yield (8.1 vs. 7.0 kg) and longer days to peak (46.6 vs. 33.2 days) than Horro. Initial and peak milk yield showed a curvilinear trend with parity. Both initial and peak milk yield increased till fourth parity then started to decline. Cows in the first and sixth parities had significantly ($p < 0.001$) the lowest initial and peak milk yield compared to cows in the other parities. Debre Zeit herd had significantly (at least $p < 0.05$) higher initial milk yield (5.1 vs 4.5 kg), shorter days to peak (33.2 vs 46.6 days) and higher PI (89.2 vs 85.8 %) than the Bako herd (Tables 2 & 3).

Highest initial milk yield was observed for cows that calved during Gana (rainy season), while peak yield and days to peak milk yield were highest for cows that calved during Arfasa (short rainy season) and Bona (dry season). Highest PI was observed for cows that calved during Birra (post-rainy season) (Table 3). Significantly (at least $p < 0.05$) highest initial (5.9 ± 0.35 kg) and peak milk yield (8.5 ± 0.32 kg) were observed for cows that calved in

1981 while the longest days to peak milk yield was recorded for cows that calved in 1991 (53.7 ± 8.09 days; Table 2).

Covariance analysis of initial and peak milk yield, days to peak and PI on calving weight showed that all traits were linearly ($p < 0.001$) related to cow weight at calving. Similarly, days to peak yield and PI were linearly ($p < 0.001$) related to initial milk yield (Table 2 & 3). Correlation analysis of initial and peak milk yield, days to peak yield, lactation yield, lactation length and PI with calving weight indicated significantly positive correlation (range r = 0.148 to 0.826; $p < 0.001$), while the correlation of days to peak with calving weight was negative (r = -0.229). Besides, initial and peak yield, lactation length and lactation yield were positively correlated between each other (Table 4).

Discussion

In characterizing lactation curve the traits initial and peak milk production, days to peak and persistency index indicate where the curve starts and peaks, number of days required to peak and the shape of the curve after peak production is reached. In this study, the least square mean values of initial milk yield, peak milk yield, days to peak and PI were 5.5 ± 0.07 kg, 8.2 ± 0.17 kg, 44.0 ± 1.17 days and 86.2 ± 0.70 %, respectively. These values are comparable to the reported values in the literature (Haresign, 1979; Ibeawuchi, 1988; Singh *et al*., 1989, Kumar *et al*., 1999). However, it is lower than peak yield reported by Koley *et al.* (1981), Rao and Sundarsen (1982), Hahn (1988) and Gashaw (1994). The variation in the values of the traits among the different studies could be due to differences in genotypes used, the non-genetic factors that affect the trait and variations in the objectives of the different farms (Gill *et al.*, 1971; Madsen, 1975; Koley *et al.*, 1981; Gashaw, 1994; Mureja, 1994). The higher values reported by Mureja (1994) for instance was based on data from commercial dairy farms where the farms objective is high milk production for sale and is based on higher grade Friesian crossbred cows, while this study is based on data from experimental stations where the management is not highly intensified to exploit the genetic potential of the animals for milk production. This might have resulted in lower values of these traits in this study compared to what Mureja (1994) reported.

Significant breed differences, in initial milk yield, peak milk yield, days to peak and PI were observed in this and earlier studies (Rao and Sundaresan, 1982; Kiwuwa *et al*., 1985; Zaman, 1988; Singh *et al.*, 1989; Gashaw, 1994).

This could be associated with the difference in genetic make up of breeds for milk production. Crossbred and higher-grade exotic breeds yielded higher milk yield compared to the indigenous breeds (Sendros *et al*., 1987; Chernet *et al*., 2000; Gebregziabher *et al*., 2003). Lactation milk yield is highly correlated with initial and peak milk yield, days to peak milk yield and persistency (Koley *et al*., 1981; Yadav and Sharma, 1985; Roy and Katpatal, 1988; Zaman *et al*., 1998). Similar correlation has been observed in this study (Table 4). High yielding cows had significantly higher values of initial and peak milk yield, longer days to peak and higher PI compared to cows with lower lactation yields. Thus, crossbred cows, which yielded higher lactation milk, gave higher values of initial and peak milk yield, longer days to peak and higher persistency compared to the indigenous breeds. This could be due to additive gene effect when *Bos indicus* (zebu) is crossed with the *Bos taurus* breeds.

Initial and peak milk yields showed a curvilinear trend with parity order having the lowest values for cows in the first and sixth parities (Table 1&2). An increase in initial milk yield up to the fourth lactation was observed. This is in agreement with the work of Yadav and Sharma (1985). Milk secretory tissue in primiparous animals takes longer to reach its peak activity than in pluriparous animals (Rao and Sundaresan, 1979), hence primiparous animals show lower initial milk yield compared to pluriparuou cows. As the heifers continue to grow, their mammary development do not reach its full maturity, more sectetory cells continue to proliferate, this might have resulted in lower initial milk yield of heifers compared to relatively mature cows. Mature cows on the other hand have matured mammary system and hence, yield higher at start of the lactation. As the lactation advances, a decrease in the number of the secretory cells results in a decrease in milk yield. The effect of parity on days to peak and PI obtained in this study was not significant which is contrary to other reports (El-Amen and Osman, 1971; Rao and Sundarsan (1979). The lactation curve for cows in the first parity and those which are low producers are flatter than lactation curves of cows in other parities and that of high producers (Yadav and Sharma, 1985) indicating lower peak milk yield and higher persistency for cows in the first parity and for those that are low producers. Similar, parity effect on peak milk yield was reported from previous works (Keown *et al.,* 1986; Kabuga and Agyemang, 1984; Bhutia *et al*., 1989) but others (Bhutia *et al.,* 1988;

Singh and Gopal, 1982) reported non significant parity effect on peak milk yield.

Table 1. Mean square, coefficient of variation (CV%) and R^2 from least square analysis of variance of initial milk yield, peak milk yield, days to peak milk yield and PI

Source	Df	Initial milk yield	Peak milk yield	Days to peak	PI
Sire breed	4	500.2 ***	797.9 ***	7632.5 ***	48.6 *
Dam breed	1	1.0 NS	148.5 ***	19403.5 ***	3.6 NS
Calving year	18	33.1 ***	22.2 ***	1909.8 *	-
Calving season	3	39.9 ***	53.6 ***	28166.5 ***	1226.8 ***
Parity	5	47.1 ***	40.9 ***	395.2 NS	314.7 NS
Location	1	54.7 **	9.9 NS	7708.4 *	1467.4 **
Regression					
Initial milk yield	1	-	-	26661.6 ***	908.7 *
Calving weight	1	510.1***	603.5 ***	10785.7 **	718.6 *
Error df		1279	1273	938	478
Error mean square		5.7	5.4	1323.3	145.8
CV (%)		43.3	28.3	82.7	13.9
R^2 (%)		53.5	63.3	19.3	10.9

Significance level: *** = p < 0.001; ** = p < 0.01; * = p < 0.05 NS =not significant

Significant differences were observed between locations and among calving seasons and years in initial milk yield, peak milk yield and days to peak milk yield. Difference between locations could be related to differences in herd management. Besides, variations in the availability of feed both in quality and quantity also contributes to calving season and year variations. Similar results were reported for peak milk yield, days to peak and PI (Rao and Sundersan, 1981; 1982; Mureja, 1994; Zaman *et al.*, 1998). Raheja (1982) reported that cows that calved during cold comfort season took comparatively shorter time to attain peak in all genetic groups they considered that could be attributed to favorable climatic conditions and availability of fodder of good quality during this season, which is in agreement to the shortest days to peak and higher initial milk yield obtained for cows that calved during Gana (wet season) in this study (Tables 2&3).

Cow weight at calving was linearly and directly related to initial and peak milk yields and inversely related to days to peak and PI (Tables 1, 2 and 3) probably associated with the age of the cows and availability of body reserve for high milk production. More mature cows which are relatively heavier at calving showed higher initial and peak milk yield and shorter days to peak and lower PI compared to lighter cows at calving. After calving the metabolic activity of secretory cells is dependent on the availability of nutrients in the blood that are used in milk synthesis (Chilliard, 1992). The closer relationship which exist between milk yield and energy balance is highly correlated during early lactation. Individual cows meet their energy demands through combinations of feed intake and mobilization of body reserve (Butler *et al.*, 1981). Thus, heavier cows and cows with greater body reserves at calving and the ability to use these reserves during the postpartum period can partly overcome the negative energy balance during earlier lactation, which probably resulted in higher initial and peak milk yield (Coppock *et al.*, 1974; Butler *et al.*, 1981). Moreover, the ability to rapidly mobilize body reserve for milk production during early lactation might enabled the cows to reach their peak yield within shorter period of time and lower the persistency of lactation. Initial milk yield was inversely related to days to peak and PI (Table 4) indicating that an increase in initial milk yield results in shorter days to peak and lower PI.

Correlation (Table 4) of peak milk yield, lactation length, initial milk yield and lactation yield with calving weight are positive (range r = 0.312 to 0.836; $p < 0.001$). The positive correlation reported (Singh and Gopal, 1982; Koley *et al.,* 1981) between peak milk yield and lactation yield and negative correlation of initial milk yield with days to peak (Bhutia and Pandy, 1988) is consistent with the present work (Table 4).

Table 2. Least square means (± SE) initial and peak milk yield (kg), and days to peak yield

Source	**N**	**Initial yield**	**N**	**Peak yield**	**N**	**Days to peak**
Overall mean	1313	5.5 ± 0.07	999	8.2 ± 0.17	973	44.0 ± 1.17
Sire breed		***		***		***
Friesian crosses	651	6.5 ± 0.13 [b]	339	8.9 ± 0.13 [b]	331	45.3 ± 2.65 [a]
Jersey crosses	183	7.1 ± 0.22 [a]	179	9.9 ± 0.21 [a]	176	47.3 ± 3.65 [a]
Simmental crosses	124	6.1 ± 0.25 [b]	118	9.7 ± 0.25 [a]	116	49.4 ± 4.32 [a]
Horro	255	3.3 ± 0.25 [d]	253	5.5 ± 0.25 [c]	250	30.7 ± 4.52 [b]
Boran	100	2.5 ± 0.25 [c]	110	3.9 ± 0.26 [d]	100	26.8 ± 4.16 [b]
Dam breed		NS		***		**
Boran	794	5.1 ± 0.12	489	8.1 ± 0.16 [a]	471	46.6 ± 2.22 [a]
Horro	519	5.1 ± 0.19	510	7.0 ± 0.20 [b]	502	33.2 ± 3.03 [b]

Table 2. Continued.

Source	N	Initial yield	N	Peak yield	N	Days to peak
Location		**		NS		*
Bako	787	4.5 ± 0.14 [a]	780	7.4 ± 0.12 [a]	762	46.6 ± 2.02[a]
Debre Zeit	526	5.1 ± 0.25 [b]	219	7.8 ± 0.25 [b]	211	33.2 ± 4.39[b]
Season of calving		***		***		***
Gana (June-August)	283	5.5 ± 0.17 [a]	209	7.7 ± 0.17 [ab]	205	30.0 ± 3.05 [c]
Birra (Sep. –November)	293	4.7 ± 0.17 [b]	207	7.0 ± 0.17 [c]	204	37.2 ± 3.11 [b]
Bona (Dec. –February)	303	4.9 ± 0.17 [b]	253	7.5 ± 0.16 [b]	243	56.3 ± 2.85 [a]
Arfasa (March-May)	434	5.3 ± 0.15 [a]	330	8.0 ± 0.15 [a]	321	36.1 ± 2.64 [bc]
Parity		***		***		NS
1	262	4.2 ± 0.19 [c]	188	6.8 ± 0.18 [c]	184	38.3 ± 3.24
2	229	5.2 ± 0.19 [ab]	162	7.9 ± 0.19 [a]	155	41.1 ± 3.48
3	256	5.5 ± 0.18 [a]	200	8.0 ± 0.17 [a]	196	41.9 ± 3.11
4	227	5.5 ± 0.19 [a]	176	8.0 ± 0.18 [a]	170	41.1 ± 3.38
5	170	5.4 ± 0.21 [a]	141	7.7 ± 0.20 [ab]	139	38.8 ± 3.64
6	169	4.8 ± 0.22 [b]	132	7.2 ± 0.21 [bc]	129	38.2 ± 3.93
Calving year		***		***		*
1980	71	5.8 ± 0.37[ab]	64	8.4 ± 0.36[a]	63	42.5 ± 5.91[abcde]
1981	79	5.9 ± 0.35[a]	78	8.5 ± 0.32[a]	76	44.1 ± 5.31[abcde]
1982	100	5.2 ± 0.33[bcd]	98	7.9 ± 0.31[abc]	96	42.6 ± 4.96[abcde]
1983	63	3.4 ± 0.37[fg]	64	7.2 ± 0.35 [def]	62	50.2 ± 5.59[ab]
1984	36	4.1 ± 0.44[defg]	39	7.1 ± 0.41 [def]	35	35.9 ± 6.81[abcde]
1985	43	4.3 ± 0.42[def]	42	7.5 ± 0.39[bcdef]	42	35.1 ± 6.31[cde]
1986	64	4.8 ± 0.36[cde]	63	7.3 ± 0.33[cdef]	63	31.8 ± 5.37[e]
1987	47	4.9 ± 0.39[bcd]	49	7.8 ± 0.36[abcde]	46	47.6 ± 5.89[abcd]
1988	44	5.9 ± 0.40[ab]	47	7.8 ± 0.37[abcde]	44	37.1 ± 6.05[abcde]
1989	19	5.7 ± 0.56[abcd]	19	7.7 ± 0.55[abcdef]	19	31.2 ± 8.72[e]
1990	112	4.9 ± 0.25[de]	109	8.0 ± 0.24[abc]	68	35.8 ± 4.66[bcde]
1991	48	3.6 ± 0.36[g]	49	7.1 ± 0.35[def]	22	53.7 ± 8.09[a]
1992	66	4.5 ± 0.32[def]	64	7.3 ± 0.31[def]	32	42.7 ± 6.62[abcde]
1993	77	4.4 ± 0.29[efg]	81	7.1 ± 0.28[ef]	34	30.6 ± 6.41[e]
1994	93	3.9 ± 0.27[fg]	97	6.5 ± 0.26[f]	51	33.5 ± 5.44[de]
1995	108	5.2 ± 0.25[bcd]	109	7.9 ± 0.24[abcd]	66	36.3 ± 4.75[abcde]
1996	70	5.1 ± 0.31[cde]	68	7.5 ± 0.30[cdef]	42	39.8 ± 5.93[abcde]
1997	83	5.4 ± 0.29[abcd]	83	8.4 ± 0.28[ab]	57	37.1 ± 5.16[abcde]
1998	90	4.5 ± 0.29[def]	84	6.6 ± 0.28[f]	55	49.9 ± 5.27[abc]

Table 2. Continued.

Source	**N**	**Initial yield**	**N**	**Peak yield**	**N**	**Days to peak**
Covariate						
Calving weight		0.014 ± 9.48***		0.02 ± 10.1***		-0.082 ± 0.03***
Initial milk yield						-2.26 ± 0.05***

Means in a column in a group with different superscript vary significantly (*** = p < 0.001, ** = p < 0.01,
* = p < 0.05, NS = not significant

Table 3. Least square mean (± SE) PI

Source	**N**	**PI (%)**
Overall mean	311	86.2 ± 0.70
Sire breed		*
Friesian crosses	142	86.6 ± 0.96 [bc]
Jersey crosses	72	89.1 ± 1.76 [ab]
Simmental crosses	73	91.4 ± 1.83 [a]
Horro	11	83.6 ± 4.03 [bc]
Boran	13	81.0 ± 3.60 [c]
Dam breed		NS
Boran	388	85.8 ± 1.29
Horro	102	86.9 ± 1.71
Location		**
Bako	236	83.5 ± 1.27 [a]
Debre Zeit	75	89.2 ± 1.75 [b]
Season of calving		***
Gana (June – August)	67	87.7 ± 1.59 [a]
Birra (Sept.– Nov.)	56	89.6 ± 1.67 [a]
Bona (Dec. – February)	86	85.4 ± 1.62 [a]
Arfasa (March – May)	102	82.7 ± 1.51 [b]
Parity		NS
1	116	88.2 ± 1.77
2	96	86.9 ± 1.70
3	106	85.4 ± 1.61
4	93	86.2 ± 1.69
5	49	86.8 ± 2.03
6	35	84.6 ± 2.32
Covariates		
Calving weight		-0.015 ± 0.01***
Initial milk yield		-0.54 ± 0.22 ***

Means in a column in a group with different superscript vary significantly (*** = p < 0.001, ** = p < 0.01, * = p < 0.05, NS = not significant

Table 4. Correlation analysis of initial (INY), peak milk yield (PKY), lactation length (LAL), lactation yield (LYLD), days to peak (DPKY) , persistency index (PI) and calving weight (CWT)

	INY	PKY	LAL	LYLD	DPKY	PI
CWT	0.533 ***	0.568***	0.148***	0.447***	-0.229 ***	-0.059 ns
INY		0.836***	0.312***	0.701***	-0.299 ***	-0.116 **
PKY			0.392***	0.826***	-0.135 ***	-0.154 ***
LAL				0.706***	0.041 NS	0.215 ***
LYLD					-0.001 NS	0.099 *

Significance level *** = p < 0.001, ** = p < 0.01, * = p < 0.05 and NS = non significant

Conclusion

The following conclusions could be drawn from this work

- The overall mean initial and peak milk yield were lower and days to peak shorter and PI comparable to other studies. Crossbred cows had higher initial and peak milk yield, longer days to peak than indigenous breeds. This indicates that those traits are improved through crossbreeding.
- Apart from the breed difference observed in this study, the traits were affected by non-genetic factors such as calving weight, calving season and year, location and parity of the cow.
- All traits were related to cow weight at calving and heavier weights resulted in higher initial and peak milk yield and shorter days to peak and lower persistency.
- The PI used to measure persistency of lactation takes 305 days lactation yield except the ascending phase. Since most of the indigenous cows had shorter lactation period, they were not included in the calculation of PI. Hence, such measure of persistency might not be appropriate to use for cows with short lactation period. Therefore, appropriate persistency measures, for cows with short lactations, need to be sought and evaluated.

Acknowledgement

This paper is a result of a thesis work by the first author at Alemaya University, Ethiopia under the supervision of the co-authors. It is based on existing data at Bako Agricultural Research Centre of Oromia Agricultural Research Institute (OARI) and Debre Zeit Research Station of the International Livestock Research Institute (ILRI). The authors are grateful to both institutions for providing their highly valuable data and computing facilities and for those who have participated in data collection and analysis in both Institutions. Besides, the authors are grateful to the OARI and the Agricultural Research Training Project of the Ethiopian Agricultural Research Organisation for their financial support.

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