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GENETIC TREND AND HERITABILITY ESTIMATES FOR MILK PRODUCTION TRAITS OF JERSEY BREED IN ETHIOPIAN HIGHLAND ENVIRONMENT

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ABSTRACT: *The purpose of this study was to assess the genetic merit of Jersey breed under Ethiopian highland environment for further improvement. The long-term performance data (from 1986 to 2016) of Jersey cattle imported from Denmark and maintained at Adea Berga, central highland of Ethiopia was evaluated. Variance components, heritability, repeatability, genetic and phenotypic correlations and estimated breeding values for three milk production traits of Jersey cows were estimated by WOMBAT software while genetic and phenotypic trends were estimated by SAS 2004 software using regression analysis. Heritability estimates for LMY (lactation milk yield), DMY (daily milk yield) and LL (lactation length) were 0.128, 0.113 and 0.037 respectively, while the corresponding repeatability estimates for these traits were 0.33, 0.37 and 0.1 respectively. The magnitude of correlations were ranged from low with negative value -0.04 (DMY-LL) for phenotypic correlations to highly positive value with 0.97 (LMY-LL) for genetic correlations. The estimated annual genetic progress for LMY, DMY and LL were 2.46 kg, 0.0043 kg and 0.175 days indicating annual increase in breeding values over the study period. On the other hand the annual phenotypic trends for LMY and DMY were negative (-8.1 kg and -0.44 kg respectively) which mean directed into unfavorable direction but for LL it was small and positive (1.02 days).*

KEYWORDS: Adea Berga, Genetic Trend, Heritability, Jersey, Phenotypic Trend

INTRODUCTION

Ethiopian farmers particularly in the outskirt areas of the country largely reared indigenous cattle for milk production and indigenous cows are characterized as low milk producers. Milk obtained from those cows could not be achieve the demand in the country. From this point of view, dairy improvements has been done at national level through introducing high yielding pure HF (Holstein Friesian) and Jersey sire/breeds targeted more extensively at crossbreeding. In the urban and peri urban areas, smallholder farmers and commercial milk producers were reared crossbred and somewhat pure exotic breed cows for milk production and the dairy production is now steadily grow up. Exotic breeds such as Holstein Frisian and Jersey have been found mostly in the private commercial and governmental research farms.

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Several authors have suggested that Jersey breed is internationally regarded as a specialized breed for milk yield with high fat, protein, and total solids contents (Cunningham and Syrstad 1987; Stocco et al., 2017). The inherent genetic attributes (early mature, good temperament, low maintenance requirement, high milk fat content, high fertility status, longer herd life and adaptation of wide range of environmental condition) of Jersey, the breed is more likely chosen in the tropical dairy development. Jersey cows excel with 18% longer productive life than other dairy breeds (U.S. Jersey, 2014). Moreover, Jersey is an ideal breed for crossbreeding with *Bos indicus* to produce a hardy, disease-tolerant, dairy-type cow that does not need a high plane of nutrition to produce reasonable milk yield and is suited to dairying in the communal areas (Imbayarwo-Chikosi, 2010). Now many dairy producers showed a renew interest that change from Holsteins to Jersey due to increasing economic pressures and Jersey breed make more profit per acre than other larger breeds (Kumar et al., 2015).

Most research agrees that the Jersey probably originated from the adjacent coast of France, where in Normandy and Brittany cattle resembling Jerseys are found. Jersey cattle are now found in at least 82 countries around the world, demonstrating their adaptability to a wide range of climatic and geographical conditions (Huson et al., 2020) with some of the largest population in countries such as United Kingdom, Australia, Canada, Denmark, New Zealand, South Africa, USA, and Zimbabwe. Recently these countries have been the source of seed stock for national Jersey herds in the Central and South American countries (Brazil, Guatemala, Argentina, Peru, Uruguay, Colombia, Venezuela and Costa Rica). Mexico has become a prominent importer and breeder of Jerseys as well. Populations of Jerseys are growing in France, Japan, Germany, Italy, the Netherlands, Switzerland and Kenya (Jersey Canada, 2015).

Jersey has been introduced into Ethiopia in 1986 and established a farm at two different location in the country for commercial milk production. The breed has been adapted and reproduced more than three decades in the cool tropical highland and hot (midland) environments of the country.

Earlier time genetic parameters and performance status for milk yield traits of indigenous, crossbred and exotic breeds were evaluated at on station leve1 in the country. Their performances were reported by different researchers (Demeke et al., 2004 for Borena x Holesitien Friesian (HF), Haile et al., 2009 for Borena and Borena crosses with HF breeds, Gebregziabhere et al., 2013 for Horro x HF and Kefale et al., 2020 for Borena crosses with HF). For example, Demeke et al. (2004) reported 2355 liters of milk with 348 days of LL and 0.24 heritability value for crossbred cows while Haile et al. (2009) reported the milk yield performance of indigenous Borena was 507 liters with 240 days of lactation length and a heritability value of 0.2. Recently, high-grade (75% crossbred) dairy cows are produced 2957.5 kg of milk with 374 days of LL (Kefale et al., 2020).

The performance worth of Jersey cows at the commercial government dairy farm was reported and comparable with 50 % Holstein Friesian crosses with variable results. Hunde et al. (2015) reported the milk yield performance of pure Jersey breed in the cool tropical highland environment of Ethiopia (Adea Berga) was 2154 kg with 336 days of LL. On the other hand, in the mid altitude area of Ethiopia (wolayita Sodo) Jersey produce significantly lower (1691.6 kg of) milk with 318 days of lactation (Habtamu et al., 2009). Evaluation of Genetic parameters and genetic trends are required in animal improvement research and knowing of these are the bases of sound livestock improvement. Even though many information had generated the genetic situation of Jersey breed across the world, the genetic parameters and genetic trends of Jersey breed for milk production traits in Ethiopia were not evaluated yet (no information is available). Therefore, this study was the first to report an estimate of heritability and genetic trend for milk production traits for Jersey breed in Ethiopia.

MATERIALS AND METHODS

Study location and Data source

Retrospective phenotypic data of LMY, DMY and LL of pure Jersey cows calved from 1986 to 2019 was obtained from central Ethiopia, Adea Berga sub research center where pure Jersey breed is reared. This farm was founded in 1986 by introducing 400 pregnant pure Jersey heifers and 2 bulls from Denmark. Hunde et al. (2015) extensively discussed the geographical location, description of the farm, herd management and breeding program of the research farm.

Data editing and Statistical analysis

Prior to analysis, incomplete records were deleted/edited according to the following criteria

1. Lactation which were still in progress
2. Lactation length less than 100 days
3. Data with unknown sire and dam (animals with unknown pedigree were pruned)
4. Abortion and still birth data
5. Errors associated with animal birth date, calving date, lactation end date.

Table 1: Number of records for genetic analysis of milk production traits after data editing

	Traits			
	LMY	DMY	LL	TOTAL
No. of records	3374	3433	3435	10242

Multi variate analysis to estimate additive genetic and environmental variances, heritability, repeatability, genetic and phenotypic correlation were done using WOMBAT program developed by (Mayer, 2006) but used the updated version (2020) fitted repeatability animal model. In the Preliminary analysis, season of calving, years of calving and parity were identified as fixed effects but year and parity are only the significant source of variation and fitted in to genetic parameter analysis. The level of significance for fixed effects was done by GLM procedure of SAS 2004, version 9.0. Additive genetic, permanent

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environment and residuals are used as random effects. Parities above 8 were merged in to 8 parity record because of few records. The detailed three-step analysis were described as follows.

Step 1: preliminary Analysis of fixed effects to determine level significance

$$Y_{ijkl} = \mu + B_j + C_k + P_l + e_{ijkl}$$

Where,
Y_{ijkl} is lactation milk yield, daily milk yield and lactation length traits;
μ is the overall mean;
B_j is the fixed effect of j^{th} year of calving;
C_k is the fixed effect of k^{th} season of calving (not significant here);
P_l is the fixed effect of l^{th} parity of cow;
e_{ijkl} is random residual term.

Step 2: Analysis of variance components and genetic parameters fitted with significant fixed effects

$$Y = Xb + Za + Wpe + e$$

Where,
Y, is the vector of observations;
b, includes vector of fixed effects (year and parity in this case);
a, is the vector of solutions for the coefficients of direct animal (additive) genetic effects;
pe, is the vector of solution for permanent environmental effects;
e, is the vector of residual effects; and
X, Z and W are the correspondent incidence matrices of the fixed effects, additive genetic and permanent environmental effects, respectively.

Step 3: Genetic trends for LMY, DMY and LL were calculated by averaging the estimated breeding values of each traits with year of birth and regressing these values for birth years that gave annual genetic change. The base animals with unknown pedigree were assumed to have estimated breeding value of zero. Phenotypic trend also calculated by averaging the phenotypic value of each trait with regressing these values for birth years, which gave annual phenotypic change.

RESULTS AND DISCUSSIONS

Heritability

The estimated variance components, heritability and repeatability values of milk production traits along with their respective standard errors in this study was presented below in table 2. Heritabilities ranged from 0.037 to 0.128 for milk yield traits. Heritability was higher for

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LMY and lower for LL. Heritability value of LMY in the present study was lower compared to tropical and subtropical areas of Jersey breeds reported by (Banga, 1992; Campos et al., 1994; Roman et al., 2000; Khan, 2002; Missanjo et al., 2013; Rincón et al. 2015; Sabedot et al. 2018). As the environment is more important for the expression of genetic potential of cows, animal management practices particularly, feed and health problems influence this heritable trait. The estimated additive genetic variance for milk traits were smaller than those permanent environmental and error (unknown) variances. As a result, heritability values were lower. The lower additive genetic variance indicated that there are small or no selection were undertaken in this herd. In the literatures, heritability estimates are largely available for lactation milk yield and milk composition traits in Jersey cows but for DMY and LL, there are negligible. The present heritability values for DMY and LL was low and, it was expected that DMY and LL traits were highly correlated with LMY. The heritability value of LL was close to the report of (Khan, 2002). From the literature reported on different breeds, LL was lower heritability value compared to LMY and DMY traits (Zafer and Metin, 2009; Ayalew et al., 2017) which indicates higher influence of environments on this trait or the additive genetic effect is inflated by non-additive and environmental effects.

Table 2: Variances, heritabilities and repeatabilities of milk production traits for Jersey cows

Traits	σa^2	σpe^2	σe^2	σp^2	h^2	r
LMY	87604.9	141897	455606	685108	0.128+0.037	0.33+0.02
DMY	0.274	0.634	1.526	2.434	0.113+0.038	0.37+0.02
LL	504.377	845.741	12380.8	13730.9	0.037+0.022	0.1 + 0.02

σa^2, additive genetic variance; σa^2, permanent environmental variance; e^2, error variance;
σp^2, phenotypic variance; h^2, heritability and r repeatability

Repeatability

Repeatabilities for milk yield traits were ranged from 0.1 to 0.37. The higher repeatability was for DMY and the lower estimate was for LL. These estimates are less than (Missanjo et al., 2013). LMY trait tended to have medium repeatability estimates following DMY. This result was within the range normally accepted for USA Jersey cows (Roman et al., 2000). As shown the above table 2, repeatability estimates of milk production traits are higher than heritability estimates because repeatability include variation attributable to total genetic differences as well as permanent environmental sources of variation. As such, repeatability is sometimes known as total heritability.

Genetic and phenotypic correlations

The magnitude of correlations in this study were ranged from low with negative value -0.04 (DMY-LL) for phenotypic correlations to highly positive value with 0.97 (LMY-LL) for genetic correlations. The genetic correlation among milk production traits were very

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high. This implies that the same set of genes exerts a common influence on the genetic expression of LMY, DMY and LL. LMY was higher genetic correlation with DMY and LL. The result showed that an increasing LMY could be achieve through selection of DMY and LL. On the other hand, genetic correlation between DMY-LL was lower than LMY-DMY and LMY-LL. Compared to the present study, Ulutas et al. (2008) reported moderate genetic correlation but lower phenotypic correlation between milk yield and lactation length traits, respectively. The genetic correlations of LMY, DMY and LL for Jersey cows were higher than the corresponding phenotypic correlations. This result is disagreed with the result of Missanjo et al., 2013 who reported that the phenotypic correlations among milk yield traits (305 days milk yield, protein and fat) are higher than genetic correlation.

Table 3: Genetic and phenotypic correlations for milk production traits

	LMY	DMY	LL
LMY		0.96+0.07	0.97+0.07
DMY	0.479+0.017		0.863+0.26
LL	0.816+0.007	-0.045+0.02	

Above diagonal genetic correlations and below diagonal phenotypic correlations for milk production traits

Genetic and phenotypic trends

Genetic and phenotypic trends measure the changes in a population or a herd and are the ultimate indicators of sustainable genetic progress.

Genetic trends

The estimates for annual genetic trends for milk production traits were minimal in magnitude though in the favorable direction. Figures 1, 2 and 3 depict genetic trends (average yearly change of estimated breeding value) estimated by yearly average estimated breeding value regressed on birth year of animals for LMY, DMY and LL, respectively. The estimated annual genetic progress for LMY was 2.46 kg indicating annual increase in breeding values over the study period, which might be recent use of selected worldwide Jersey sires into the herd. Positive but small fraction of genetic progresses were also obtained from DMY and LL traits. The estimated breeding value for milk production traits are fluctuated over the study years. However, genetic improvement was seen in the herd since 2010 as shown from the trend analysis. This might be attributed to the level of selection, use of different sires with unknown breeding value over several years, and level of management system or environmental effects to express genetic potential of cows.

The present increasing genetic trend was agreed with earlier studies with inconsistent values. Musani and Mayer (1997) reported 0.8 kg of annual genetic gain for Jersey milk in the central rift valley Kenya. Ulutas (2008) reported an annual genetic change of 6.26 kg of milk per annum for Turkish Jersey. Considerable result (41 kg) of milk yield genetic

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change was reported by (Roman et al., 1999). The genetic trend of Jersey breed for milk yield in the South African is highly progressive and obtained 40.2 kg annually (Mostert et al., 2006). On the other hand, genetic trend of Jersey in the semi-arid low land of Kenya is significantly ($p<0.01$) deteriorated and -0.07 kg of LMY decreased annually (Njubi et al., 1992). Kefena et al (2011) reported negative annual genetic trend of milk production trait for crossbred dairy cows in the central highland of Ethiopia. Research reports on annual genetic trend for dairy cows are variable that might be difference in study location, herd structure, breed and selection intensity.

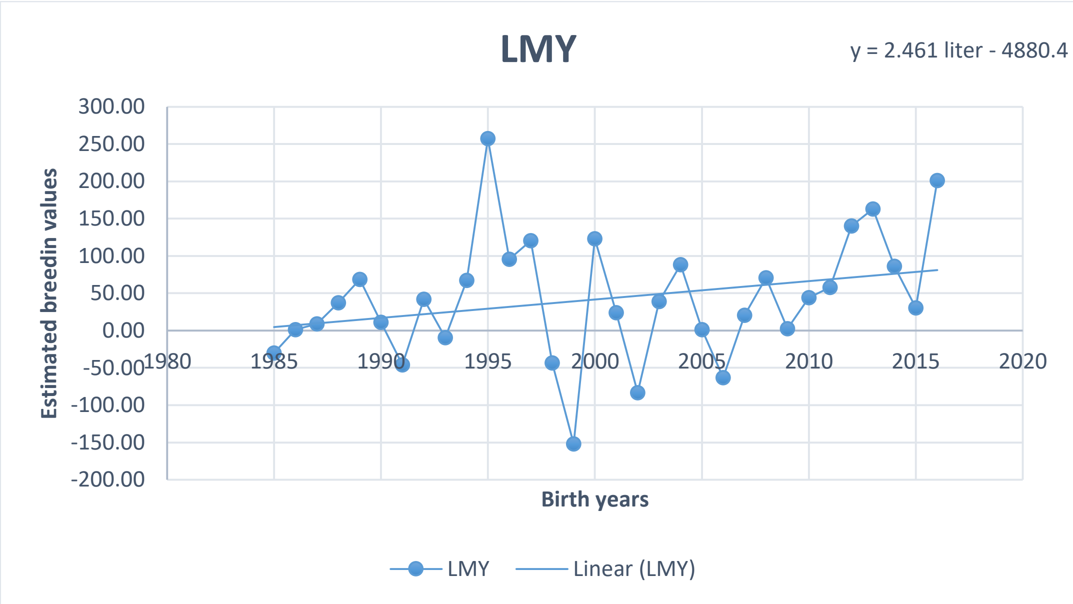

Figure 1: Genetic trend for LMY

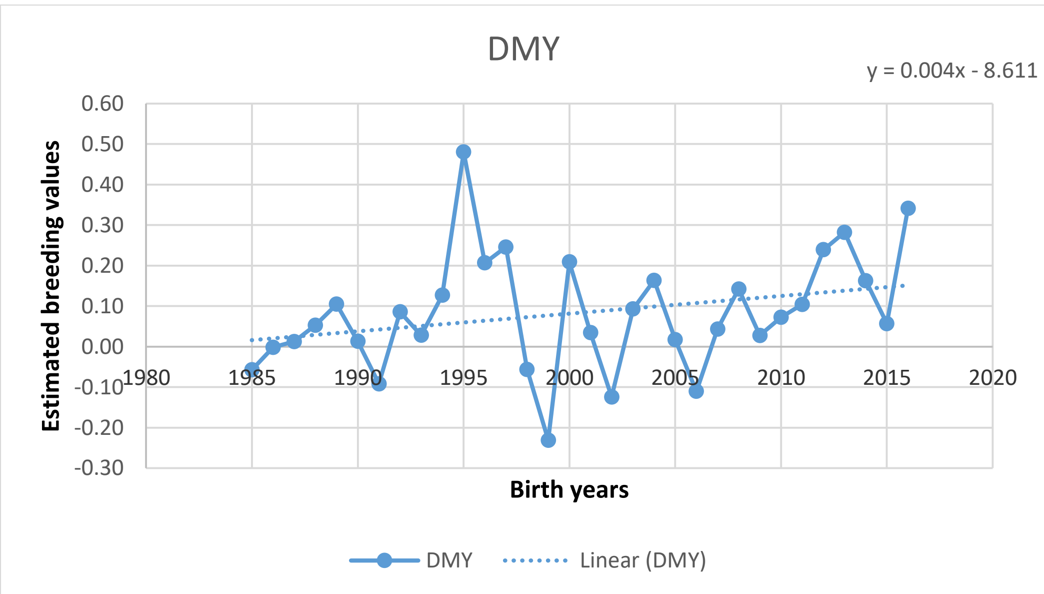

Figure 2: Genetic trend for DMY

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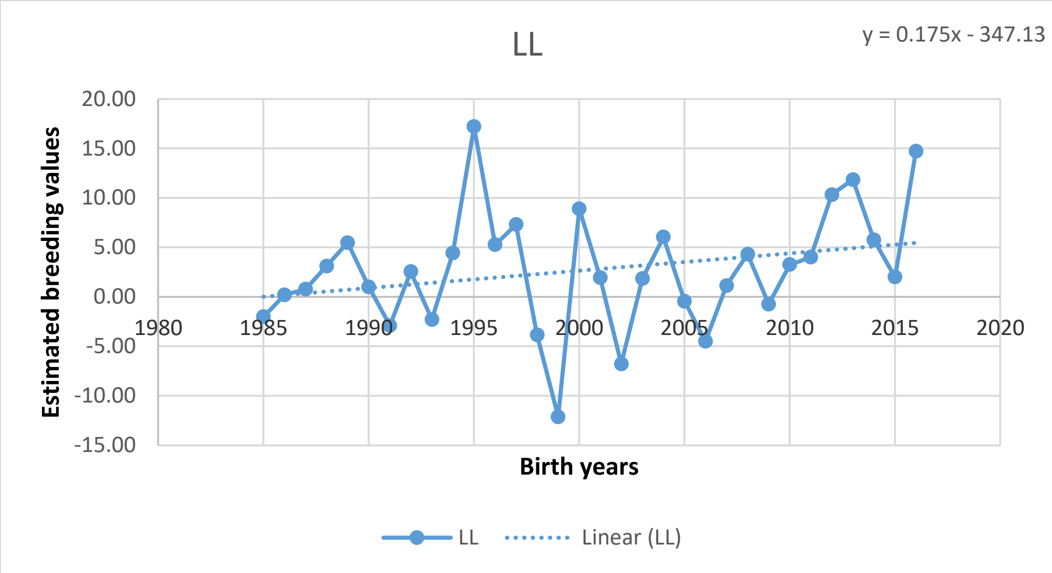

Figure 3: Genetic trend for LL

Phenotypic trends

The annual phenotypic trends for milk production traits in this study was the sum of genetic trend and environmental trend. The estimates for annual phenotypic trends for milk production traits were negative and directed into unfavorable direction. Figures 4, 5 and 6 depict phenotypic trends estimated by regressing yearly mean phenotypic values on birth year of animals for LMY, DMY and LL, respectively. There was significant ($p>0.05$) decline (-8.1 kg) of annual phenotypic trend for milk yield over the 36 years. Ulutas et al. (2008) obtained an increasing (69.8 kg) of annual phenotypic change of milk yield regressed by calving year from Turkish Jersey. There was a considerable fluctuation of phenotypic trends of LMY and DMY across birth years probably, reflecting high management difference among the years. The decreasing phenotypic trend of lactation milk yield (-8 kg) over the study period could be due to an important role of unfavorable environment i.e emphasis was not given for the environmental component in the herd. Daily milk yield was also showed similar phenotypic trend with LMY Since DMY is the fraction of LMY, the similarity of negative phenotypic trend is expected. The small positive phenotypic trend observed on LL probably indicates, Jersey cows are the ability to maintain themselves in any environmental change and producing milk for extended period. However, daily milk yield and lactation milk yield caused a gradually decreased over extended lactation length.

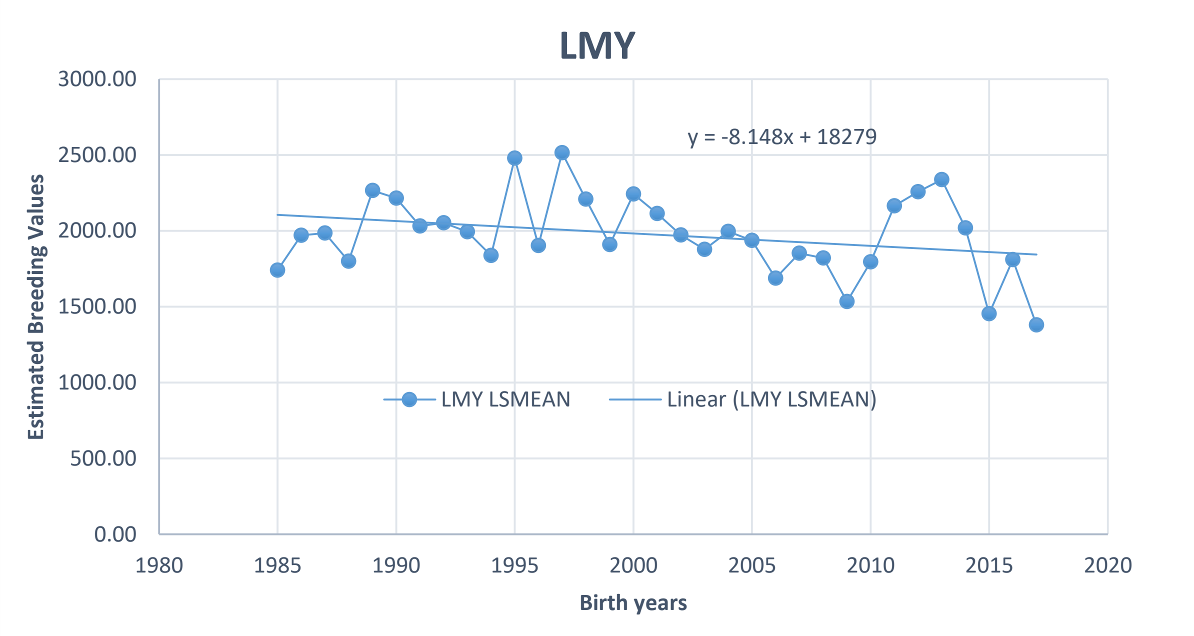

Figure 4: Phenotypic trend for LMY

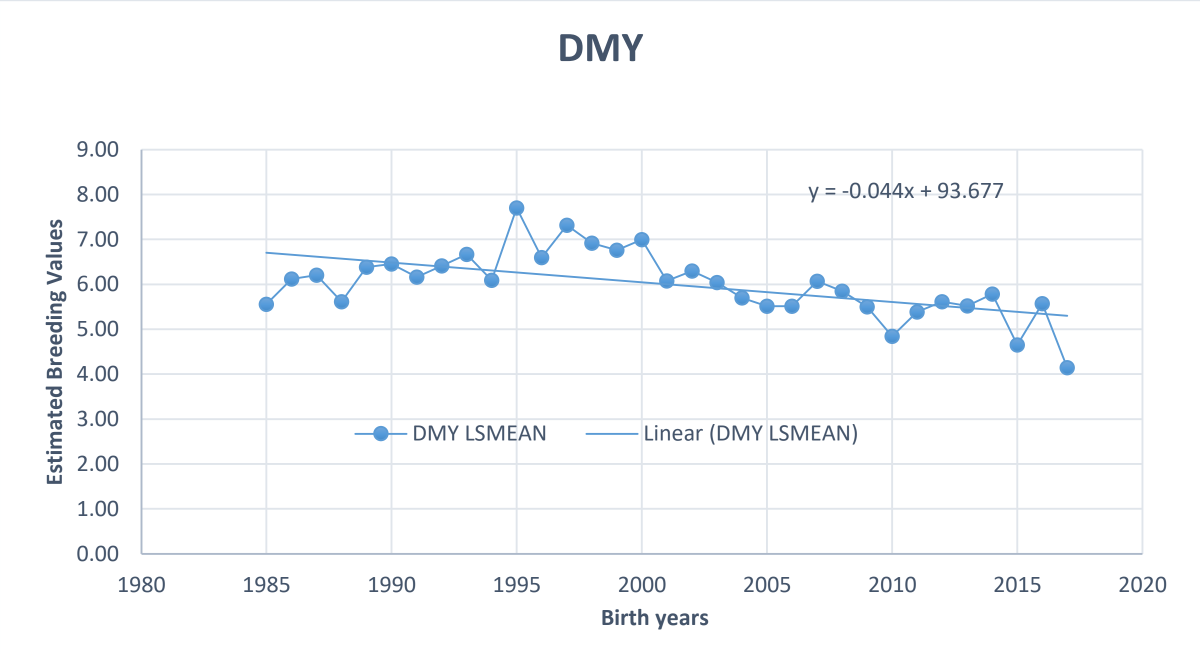

Figure 5: Phenotypic trend for DMY

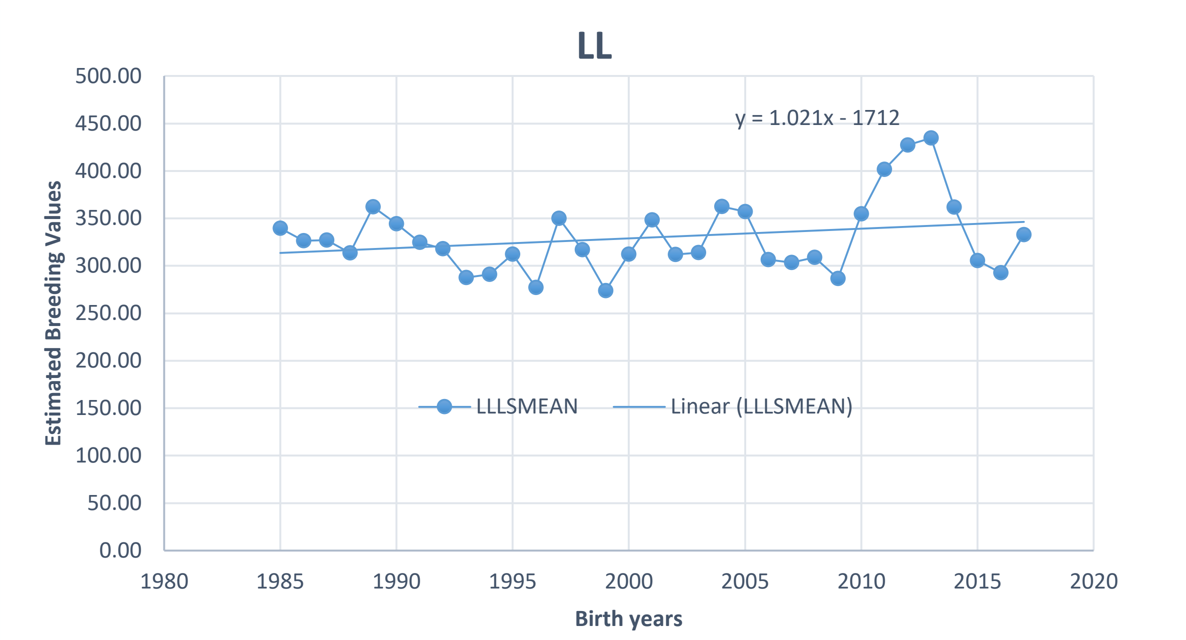

Figure 6: Phenotypic trend for LL

CONCLUSION

Knowing the genetic parameters for milk production traits of Jersey herd in Ethiopia was an important values to identify genetic and environmental variation among individuals in the herd i,e the relative importance of genetic and environmental components. The result showed that the increased milk production of pure Jersey breed in the central highland of Ethiopia was highly dependent on genetic component not environment (management), which was a major effect on milk production performance. The estimated heritability of milk production traits in this study was lower than the tropical environment reported by different authors in which environment and management influenced the traits but this will change overtime by normal management system and regular selection program. The annual rate of genetic progress observed in this study is promotable but the total phenotypic value is declined overtime and needs strong management decision to increase more profit per year. As Jersey is more productive and adaptive breed in the tropics and produced reasonable milk in Ethiopian environment, strong intervention on management and selection should be implemented for this breed in the process of developing locally adapted pure Jersey herd in our country.

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Conflict of interest

No any fund or finance are received from any organization for doing this study. Therefore, the authors declare that there are no conflict of interest related to the financial or commercial uses.

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