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Milk Productive Performances of Pure Jersey Dairy Cattle at Adea-Berga Dairy Research Center, Central Highland of Ethiopia

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Abstract: Performance evaluations for economically important milk production traits are the bases for genetic evaluation, planning breeding program and selection for dairy cows. This study was intended to evaluate milk production traits of pure Jersey dairy cows at Adea-Berga Dairy research center. The data collected from 1986 to 2019 from a herd maintained at Adea-Berga dairy research center was used to estimate milk production traits (lactation milk yield (LMY), daily milk yield (DMY) and lactation length (LL)). A general linear model procedure of the Statistical Analysis System (SAS, version 9.0) was used to analyse the milk performance data. The result of fixed-effect analysis revealed that the influence of year and parity caused significant ($p<0.0001$) variation in all milk production traits. However, season of calving does not significantly affect milk production traits. Knowledge on the effect of these non-genetic factors for milk production would help in making management decisions for improvement of the herds. The overall least squares mean (LSM±SE) for LMY, DMY and LL were 2166.10±26.71 Litres, 6.37±0.05 Litres and 344.89±3.81 days, respectively. In conclusion, the results of this study suggest that the improvement of milk production traits of the pure Jersey cattle population at Adea-Berga dairy research center is possible through improving the level of feeding, breeding and health management than through genetic selection.

Keywords: Milk, Production Traits, Pure Jersey Cows

1. Introduction

Ethiopia is one of the developing countries in Africa known with a huge livestock population. The demands for dairy products are estimated to increase substantially as the human population increase in Ethiopia. In response to the increasing demand for dairy products, the Ethiopian government has been efforted to improve milk productivity in the dairy sector, through intensive husbandry with cross and exotic breeds [1, 2]. However, the dairy sector in Ethiopia is still not developed as compared to east African countries like Kenya, Tanzania and Uganda [3].

Holstein-Friesian and Jersey dairy breeds are the most common highly productive and important sources of milk, milk product and income, especially in urban areas. Pure exotic dairy cattle in Ethiopia were a concern about adaptation problems to the tropical environment such as feed, disease challenge and climate. Pure HF and Jersey dairy cows have been utilized by large scale private and state dairy farms in Ethiopia. Improved exotic dairy cattle would potentially serve milk supply and used as a genetic pool for the national animal genetics improvement institute (NAGII) to recruit artificial insemination (AI) bulls for the genetic improvement program of the country [4].

Milk production traits are the most economically important traits, contributing to the profitability of dairy production [5]. The common measures of milk production performance of dairy cattle traits are lactation milk yield (LMY), daily milk yield (DMY) and lactation length (LL).

Jersey breed cows could be a good alternative in the central highland Ethiopian to use as an additional option for intensive, large and small scale dairy farms as well as a genetic pool for genetic improvement activities. However, there is limited information on milk production performance traits of pure exotic Jersey breed under different dairy management systems in Ethiopia. Therefore, the objective of this study was to evaluate the milk production performances of pure Jersey dairy cows maintained at Adea-Berga dairy research center in the last 33 years.

2. Materials and Methods

2.1. Description of the Study Area

The current research was conducted at Adea-Berga dairy research center which is found in West Shewa Zone of Oromia regional state of Ethiopia. Adea-Berga wet land is located in the central highland of Ethiopia at 70 km away to the West of Addis Ababa and 35 km to the North West of Holeta (at 9°16' N latitude and 38°23' E longitudes, altitude of 2500 m above sea level). It is characterized by cool sub-tropical climate with the mean annual temperature and rainfall of 18°C and 1225 mm, respectively. The vegetation is mainly perennial grasses and sedges. The most common grass species in the area are *Trifolium*, *Pennisetum* and *Andropogon* [6].

2.2. Description of the Farm

The farm was established in 1986 for commercial milk production under government state farm using 400 pure Jersey pregnant heifers and 2 sires (foundation stock) introduced from Denmark. The total area of the farm has 400 ha of land. Animal barn, office and residence were constructed on about 10 ha of land and the rest of land is being utilized for grazing and hay production. The whole pasture land is protected during main rainy season for hay production and also all animals are confined to the barn during this period. The farm had been engaged in the production and rearing of pure Jersey breed from the foundation stock for milk supply for dairy development enterprises and also serve as a bull dam station for the national animal genetics improvement institute (NAGII). Then the farm was transferred to Holeta Agricultural Research Center for genetic improvement research program since 2007. The objectives of the farm were to increase milk production through pure breeding and production of pure breed Jersey bulls for AI and Natural mating (NM). The production system of the farm is semi-intensive production system.

2.3. Animal Management

Herds are managed separately depending on sex, age, pregnancy and lactation (dry or milking). Female calves were allowed to suckle their dam immediately after birth for about five days to receive colostrum and then separated from their dams and offered fresh milk twice a day for about 6 months. However, male calves were weaned within 98 days. Calf weighting and ear tagging were also engaged within 24 hours after birth. Cows and heifers were allowed to graze natural pasture for about 4 hours a day and supplemented with hay, silage and concentrate feeds up on return to the barn during the dry and small rainy seasons. The animals had free access to clean tap water all the time. All animals were restricted from grazing and managed indoor during main rainy season. Calves less than 6 months, bulls and late pregnant cows and heifers were usually isolated and managed indoor. All animals were supplemented with hay and concentrate feeds constituting 60% wheat bran (sometimes with wheat middling), 38% noug seed cake (*Guizotia abyssinica*) and 2% salt. The amount consumed is not exactly known, since it depends up on the amount of feed available on the stock.

Milking machine was used for about one year in between 1988 and 1989. However, due to shortage of spare part and skilled man power for maintenance of the machine, the farm was forced to implement hand milking. Milking was done twice a day at equal interval (in the morning and afternoon) and the milk produced by each cow was measured and recorded on prepared format immediately after milking. Routine vaccination was conducted against Blackleg, Anthrax, Pasteurellosis, Foot and mouth disease and Lumpy skin disease. Animals were de-wormed against internal parasites and treated against other infectious diseases by tentative diagnosis.

2.4. Breeding Program

Pure breeding program was carried out on imported foundation stock that constitutes 400 pregnant heifers and two sires. Controlled mating program was practiced and both natural mating and artificial insemination technique were used. national animal genetics improvement institute (NAGII) rarely introduce new exotic Jersey semen since this farm has been used as a bull dam station for national semen production to dispatch Jersey semen for national crossbreeding activities. Thus, very few young bulls were recruited based on dam performance and physical conformation for NAGII semen collection to assist on farm cross breeding activities at national level. The rest of the male calves were culled from the farm at an early age. Genetic improvements of the herd was now undertaking by importing worldwide sires and inseminate the cows to increase genetic variability among animals.

Cows in heat were detected by teaser bull and herd men during grazing time and by guards during night time and these personnel were responsible to notify AI technicians on time. The mating date and sire identification number were recorded on herd book for every insemination and then transferred to individual cow card. Mating was continuous and allowed throughout the year. Served cows and heifers were pregnancy tested by rectal palpation at about two to three months after insemination.

2.5. Data Source and Data Collection

The data for this study was obtained from long-term records of pure Jersey breed that has been kept for dairy production in Adea-Berga dairy farm. There are four main recording formats; the first is a herd book containing daily breeding activity, the second is milk record format which contains daily milk yield, the third is health record and the fourth is individual card record in which individual complete data is prepared or transferred from herd book. Individual cards contain birth date, individual tag number, sex of calf, calf birth weight, dam and sire, service date, service sire, calving date, milk yield records, disposal date, cause of disposal and other reproductive and production data. There was computerized data base in the farm. Recorded data for the last 33 years (1986-2019) on milk production data were used for this study.

The data used in this study were collected from 1986 to 2019 from individual animal card history and from the center database for the subsequent trait analysis. Identification number of each cow date of calving, parity of cow, animal group, lactation milk yield (LMY), daily milk yield (DMY) and lactation length (LL) data were collected from the farm data base.

2.6. Data Management and Description of Fixed Effects

Milk production performance data collected from 1986-2019 at Adea-Berga dairy research center were used for this study. Microsoft Excel was used to arrange and filter milk production data. Data screening of data was made to avoid errors during data entrance and editing. Cows that had abnormal calving (*i.e.*, abortion and stillbirths) were not included in the model analysis. During data editing lactation records having less than 100 days were removed from data set for analysis of lactation milk yield and lactation length. Lactation records of sixth and above parities were pooled due to few numbers of observations.

The major genetic and non-genetic effects were classified into different sub-classes in order to quantify their effect on the milk performance traits. The fixed effects were animal group, year, season and parity.

Animal group: Includes imported and farm bred (farm bred animals were the progeny of imported animal which have been raised in the farm).

Calving years: Years which used for this study were spread over span of 33 years and thus there could be variation in the expression of different economic traits over the years due to the effect of changing climatic, feeding and management factors in the herd. However, this effect might be insignificant to quantify for each year separately. This has been initially done and it was learnt that the economic traits didn't vary over the years in a consistent and meaningful manner as well as variation of number of observations. Consequently, it was decided to use period (year group) to account for its effect. Thus, the entire duration was classified in to 10-11 periods based calving years; each year period represents three years.

Calving seasons: Calving seasons are considered as one of the environmental factors that affect the expression of economic milk production traits. Thus, based on the meteorological information that considered rainfall, temperature and relative humidity the three calving seasons were identified. Thus, the three seasons were dry season (October, November, December, January and February), short rain season (March, April and May) and main rain season (June, July, August and September).

Parity: Each cow included in the study contributed variable number of lactation records depending on the number of calvings cows. Thus, parity was fitted as fixed effect to account for its effect on milk production traits. So, parity was grouped in to six classes (1, 2, 3, 4, 5 and ≥6). All parities above six were pooled with the 6^{th} parity because the available numbers of calving cow with parity greater than six were too small to constitute separate groups.

2.7. Statistical Analysis

Preliminary data analysis like screening of outliers and normality test were employed before conducting the main data analysis. Effects of non-genetic factors (animal group, calving period, calving season and parity) and least squares mean for milk production traits (LMY, DMY and LL) were analyzed by the GLM procedures of SAS (2004) version 9.0 software. Differences between least squares means of a trait for different genetic and non-genetic factors were tested using the Tukey-Kramer test based on the ANOVA result. Fixed effects which are significant ($P<0.05$) were fitted into the model. The statistical model for the three milk production traits was as follow:

Model: Statistical model for analysis of milk production traits (LMY, DMY and LL):

$$Y_{ijkl} = \mu + Y_i + S_j + G_k + P_l + e_{ijkl}$$

Where:

Y_{ijkl} = LMY, DMY and LL of $_{ijkl}$ cow with i^{th} year, j^{th} season, k^{th} genetic group and l^{th} parity

μ = overall mean;

Y_i = the fixed effect of i^{th} period of calving (i= 1986 to 2019)

S_j = the fixed effect of j^{th} season of calving (dry, short rain and main rain season)

G_k = the fixed effect of k^{th} animal group (imported and farm bred)

P_l = the fixed effect of 1^{th} parity (l = 1, 2, 3, 4, 5 and ≥6)

e_{ijkl} = random error associated with each observation.

3. Results and Discussion

Milk production performance traits: the lactation performance of dairy cow is usually measured by determining the total lactation milk yield (LMY), average daily milk yield (DMY) and lactation length (LL).

3.1. Lactation Milk Yield (LMY)

Results of the least square means and standard errors for LMY are summarized in Table 1. The overall lactation milk yield and standard error of LMY for pure Jersey cows in the present study was 2166.82±26.70 kg. The result obtained in this study was comparable to the reports of 2155±16.4 kg and 2200.25±112 kg for Jersey breed [6, 7]. Lower lactation milk yield values 1691.59±27.55 kg for Jersey breed, 1683.34 kg for HF x Boran, 1798±25 kg for HF x Boran, 1907.56±15.14 kg for HF x Boran and 1684.1±17.6 kg for Jersey x Boran were reported by [8-11]. However, higher values 2774.18±108 kg and 3710 kg of lactation milk yield for HF breed were reported by [7, 12]. The difference of the present result from the other authors reported could be associated with breed/genetic makeup, feeding practice and climate factor in which animals were managed.

Calving period had significant effect on LMY ($p<0.0001$). This result agreed for pure Jersey breed and for Holstein Friesian crosses with Boran [6, 13]. The two calving periods (2003-2005 and 1994-1996) were the most favorable calving years for animals to perform better lactation milk yield. The highest average lactation milk yield was observed during 2003-2005 (2603.58±59.27 kg) while the lowest lactation milk yield was recorded in 1991-1993 (1730.73±55.91 kg). Low performance of cows which calved in during 1991-1993 could be related to management problems like shortage of feed and health problems as a result of regime change in which the farm was financed and funded by government. The variation in lactation milk yield from one-calving period to other could be attributed to changes in herd size, stage of lactation, change of the climate and inconsistent management (feeding) practices introduced from year to year.

Calving season did not have significant ($p>0.05$) effect on LMY. This result agreed with the finding of [7, 10, 12, 6]. On the other hand calving season did have significant effect on LMY [11, 9, 13].

The analysis of variance revealed that lactation milk yield significantly ($p<0.0001$) differed among different parity. This significant effect of parity on LMY was similar for pure Jersey breed, for Holstein Friesian crosses with Boran and for HF x Boran and Jersey x Boran [6, 13, 11]. In contrast, parity did not have significant effect on LMY for Jersey and HF cattle [7]. Maximum lactation milk yield was observed in parity two (2315.90±43.85 kg) and minimum yield was recorded in parity greater than or equal to six (1948.66±48.68 kg). The result of the present study was similar finding with a value of 6.25 kg for pure Jersey cows [4].

3.2. Daily Milk Yield (DMY)

The average daily milk yield (DMY) is a very important milk production efficiency trait, which is a combination of milk yield and lactation length. The least square means and standard errors of daily milk yield values are shown in Table 1. The overall least square mean and standard error of daily milk yield for pure Jersey cows in the present study was 6.37±0.05 kg. The result of the present study was similar finding with a value of 6.25 kg for pure Jersey cows [4].

Daily milk yield (DMY) was significantly ($P<0.01$) affected by animal group. Farm breed animals were produced higher DMY than imported animals. This variation might be due to environment difference (feeding management and climate condition) where the animals were kept. Period of calving had significantly ($P<0.0001$) affected DMY. This result was agreed for HF x Boran cross [13]. Calving season group did not show a significant effect on DMY. This result was agreed for HF x Boran cross [10].

There was significant ($P<0.0001$) difference among parity of cow on daily milk yield. This result was agreed for Jersey x Boran and HF x Boran [11, 13]. Higher daily milk yield was observed in parity five and lower was recorded at parity one. Cows with lower parities had lower daily milk yield than those of higher parities. This might be because the size of udder and teats increased with the maturity of the cows and subsequently the milk production capacity increased with parity. The highest daily milk yield recorded was during 2003-2005 and the lowest daily milk yield was recorded during 1991-1993 calving periods Table 1). Low DMY for cows which calved in during 1991-1993 could be related to management problems like shortage of feed and health problems as a result of regime change in which the farm was financed and funded by government.

3.3. Lactation Length (LL)

Lactation length (LL) is an important milk production trait as it influences the total milk yield. Least square means and standard errors of lactation length for fixed effects of animal group, calving period, calving season and parity are summarized in Table 1. The overall least square mean and standard error of LL for pure Jersey cows in the present study was 344.89±3.81 days. This result was higher than a value of 318.42±3.92 days and 336.17±2.3 days for Jersey cows, respectively [8, 6].

Analysis of variance showed that lactation length was significantly ($P<0.001$) affected by animal group. Lactation length was higher for imported cows than those reared on farm. This result is in line with the finding for Jersey cows [8]. Lactation length was significantly ($P<0.0001$) affected by fixed effect of calving period. This result is similar for Jersey cows and for HF x Boran cross [6, 13]. Highest lactation length was recorded on cows born in during 2015-2017 and the lowest was observed during 1988-1990 with a difference of 116.83 days (Table 1). The variation of LL with the different calving period might be explained by the variation of annual rainfall, which directly or indirectly is associated with the availability of feeds.

Season of calving did not influence ($p>0.05$) lactation length. This result was in line with the finding of [10, 8, 6, 13]. Analysis of variance showed that lactation length was significantly ($P<0.0001$) influenced by parity and this result was agreed with the findings of [6, 13]. The longest lactation length was observed in parity two and the shortest was recorded on parity greater than or equal to six (≥6).

Table 1. *Least square means and standard errors of lactation milk yield (LMY), daily milk yield (DMY) and lactation length (LL) of Jersey cattle.*

Sources of variation	N	LMY (Litres)	DMY (Litres)	LL (days)
		LSM±SE	LSM±SE	LSM±SE
Overall mean	2912	2166.10±26.71	6.37±0.05	344.89±3.81
CV (%)		38.52	23.81	35.62
Animal group		Ns	**	***
Imported	1048	2202.47±54.23	6.18±0.10^{b}	361.29±7.74^{a}
Farm breed	1864	2130.81±26.48	6.56±0.05^{a}	328.57±3.78^{b}
Calving period		****	****	****
1988-1990	693	2062.08±58.17^{d}	7.27±0.11^{b}	282.15±8.29^{f}
1991-1993	276	1730.73±55.91^{e}	4.27±0.10^{f}	367.81±7.97^{c}
1994-1996	275	2528.84±51.00^{ab}	6.92±0.10^{c}	365.47±7.28^{bc}
1997-1999	262	2257.29±56.26^{bc}	6.73±0.11^{c}	331.87±8.03^{cd}
2000-2002	313	2367.80±56.55^{b}	7.31±0.11^{b}	325.07±8.07^{e}
2003-2005	288	2603.58±59.27^{a}	7.62±0.11^{a}	341.88±8.45^{d}
2006-2008	254	2221.54±61.70^{c}	6.15±0.12^{d}	380.66±8.80^{b}
2009-2011	153	2143.83±74.48^{cd}	5.74±0.14^{e}	377.15±10.63^{ab}
2012-2014	194	1791.83±68.24^{e}	5.91±0.13^{de}	304.21±9.74^{bd}
2015-2017	163	2243.19±73.36^{bc}	5.75±0.14^{e}	398.51±10.47^{a}
2018-2019	41	1877.87±134.91^{de}	5.93±0.25^{de}	319.16±19.25^{ed}
Calving season group		Ns	Ns	Ns
Dry season	1517	2160.67±31.99	6.34±0.06	343.67±4.56
Short rain season	639	2192.71±38.48	6.43±0.07	349.25±5.49
Main rain season	756	2145.23±37.23	6.33± 0.07	341.79±5.31
Parity		****	****	****
1	830	2061.38±43.80^{cd}	5.75±0.08^{c}	360.81±6.25^{a}
2	722	2315.90±43.85^{a}	6.55±0.08^{a}	362.57±6.26^{a}
3	449	2132.36±45.80^{bc}	6.36±0.08^{ab}	339.95±6.53^{b}
4	341	2225.43±49.82^{ab}	6.65±0.09^{a}	343.09±7.11^{ab}
5	245	2315.11±56.85^{ab}	6.68±0.12^{a}	348.24±8.11^{ab}
≥6	325	1948.66±48.68^{d}	6.22±0.09^{b}	314.86±6.95^{c}

N= number of observations, Ns (not significant) = P>0.05, ****= P<0.0001, ***= P<0.001, **= P<0.01, CV= coefficient of variation, Least square means with different superscripts within the same fixed effect indicate statistical difference.

4. Conclusions and Recommendation

From this study, the milk production performance traits of pure Jersey dairy cattle was influenced by genetic and non-genetic factors. Animal group had significant effect on daily milk yield (DMY) and lactation length (LL) traits. Year of calving and parity had significant effect on all milk production traits. Season of calving does not significantly affect milk production traits. Knowledge on the effect of these non-genetic factors (animal group, calving period, calving season and parity) would help in making management decisions for improvement of the herds. Improvement on the level of feeding, breeding and health management should be done for improvement of milk production performance traits.

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