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Effect of Season, Parity, Exotic Gene Level and Lactation Stage on Milk Yield and Composition of Holstein Friesian Crosses in Central Highlands of Ethiopia

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Abstract

The study used twelve years recorded data's analysis for milk yield and composition of Holstein Friesian crossbred dairy cows in Holleta agricultural research center dairy farm. Data were summarized and categorized into the season, genotype (exotic blood level), Parity and lactation stages. The summarized data's were season (219 wet, 1055 dry), genotype (1,117 for 50%, 115 for 62.5% and 42 for >75%), Parity (474 for parity-2, 356 parity-3, 270 for parity-4 and 174 for parity-5), Lactation stage (483 for early, 445 for mid and 346 for late). Analysis of means and standard errors of the mean for the parameter studied was estimated using SAS. The General Linear Model was used for analyses of variance on average monthly milk yield and composition for the effects of season, parity, genotype and stages of lactation. Season significantly affected milk yield, fat, and protein percentage composition. Higher yield and fat% composition record in the dry season and higher protein% during the wet season. Genotype significantly affected milk yield where the yield of 62.5% and >75% crossbred cows were significantly higher than that of 50% crossbred cows. The difference in parity significantly affected milk yield and protein content of milk where higher milk yield and protein content was recorded in parity five. An increasing trend observed in milk yield and protein content as dam parity advances. Mean monthly milk yield, percent of protein and total solid was varied significantly between different lactation stages where protein and Total solid percentage was significantly higher in the late stages of lactation. In overall milk, the yield was significantly affected by season, genotype, parity and stages of lactation but it is negatively correlated with the percentage of fat, protein, and total solids. Season, parity and stages of lactation significantly affected the protein content of milk whereas milk composition strongly correlated with each other.

Keywords: Milk yield; Milk composition; Season; Genotype; Parity and lactation stage

Introduction

Ethiopia is the largest livestock producer in Africa having more than 59.5 million cattle, 30.70 million Sheep, 30.20 million Goats, 2.16 million Horses, 8.44 million Donkeys, 0.41 million Mules, and about 1.21 million camels and 56.53 million poultry [1]. Currently, the country production is estimated to be 1,128 Metric Tones (MT) of meat, 174 million eggs and 5.2 billion litres of milk per year [2]. The direct contribution of livestock to GDP is estimated by LSIPT at ETB 150.7 billion per year, which amounts to 17% of GDP and 39% of the agricultural GDP. This rises to about 21% of the national GDP and 49% of the agricultural GDP if the contribution of processing and marketing (35.6 billion) is taken into account. Having this amount of shares, its contribution to the Ethiopian livestock sector in general and the dairy sector, in particular, is below its potential at both the national and household level (Behnkle, 2010). To meet the ever-increasing demand for milk, milk products and their contribution to economic growth, genetic improvement of the indigenous cattle has been proposed as an option. Hence, with the aim of this, crossbreeding has been practiced for the last five decades for increasing milk output. Milk, one of the physiological products of cows, varies in amount and composition of produced during the lactation period can be affected by feeds [3,4] seasons [5-7] genotype [8-10] stage of lactation [6,11-13]. There is no enough information available to understand the effect of non-nutritional factors on milk yield and composition of crossbred cows in Ethiopia. Therefore, it necessitates doing the present data analysis to investigate the effect of season, genotype, parity and lactation stages on milk yield and composition of Holliston Friesian crossbred dairy cows kept under similar management.

Study site

The research study used data's of Holleta Agricultural Research Centre dairy Farm, in the central high lands of Ethiopia. Holletta Agriculture Research Center Dairy farm was established for research work. The farm has a pure Boran breed and its cross with different crosses level of Holstein Friesian.

Holleta

Holleta is located in the central highland of Oromia special zone surrounding Addis Ababa at a latitude of 38° 30'E, 9° 3'N and 29 km west of Addis Ababa on the high way to Ambo. It has an altitude of 2400 m above sea level and receives mean annual rainfall of 1100 mm with bimodal distribution 70% of which occurs during the main rainy season (June to September) and 30% during the small rainy season (February to April) and the annual temperature of 11 to 22°C with relative humidity of 50.4%. The soil type in the area is largely nitosol and major crops grown are teff, wheat, barley, oats, potatoes, oil crops, and pulses.

Methods

Record data analysis of Holetta agricultural research center dairy farm

The data for this study was taken from Holleta Agricultural Research Centre dairy farm. Twelve years of records of Holstein Friesian crossbred cows were used for analysis. Lactation records of cows having their second up to fifth calving between 2003 and 2014 were used for analysis. The effects of season, parity, genotype (exotic cross blood level) and lactation stage on milk yield and milk composition were evaluated. Data for analysis were classified according to the season, genotype (exotic cross blood level), lactation stage and parity. On the basis of main prevailing climatic conditions, the year was classified into two seasons, the wet season from June to September in which the area gets its major rainfall and the dry season from October to May which receives small rainfall. Those data records in these two seasons were used to see the effect of season on milk parameters. To see the effects of lactation stages on milk parameters, data's were categorized into three stages of lactation (Early stage of lactation: 7-105 days; Mid-stage of lactation: 106 to 210 days; Late stage of lactation: above 211 days). The data was further divided into 4 categories viz 2, 3, 4 and 5 parity to study the effect of parity on milk parameters. Cows were also categorized based on their genotype (exotic cross blood level) viz 50%, 62.5% and ≥ 75% exotic blood level to study the effect genotype on milk parameters.

The effects of season, parity, lactation stage and exotic cross-level on milk production and compositions will be examined using the least square technique of fitting constants.

Data management and statistical analysis

Analysis of means and standard errors of the mean for the traits studied was estimated using SAS 9.1 of 2008. The General Linear Model (GLM) will be utilized for variance analyses of data on average daily milk yield, including the effects of season, parity, Friesian cross blood level, stages of lactation and the interactions between these effects. Differences will be considered significant at p<0.05. The following model will be used to test:

$$Y_{ijkl}= \mu+a_i+b_j+c_k+d_l+ab_{ij}+ac_{ik}+ad_{il}+bc_{jk}+bd_{jl}+cd_{lk}+abc_{ijkl}+e_{ijkl}$$

In which Y_{ijkl} =is the daily milk yield

μ=the overall mean,

a_i=the effect of the season (i=dry, rainy season)

b_j=the effect of Friesian blood level (j=50%, 62.5%, 75%)

c_k=the effect of the dams parity (k=2, 3, 4,5)

d_l=effect of the stage of lactation (l=Early, Mid and Late)

ab_{ij}, ac_{ik}, bc_{jk}, ad_{il}, bd_{jl}, cd_{lk}, abc_{ijk} the respective interactions between the main effects and e_{ijkl} of the random residual effect. The interaction effect will be considered if the main effects are significant.

Result and Discussion

This paper was tried to show the effect of season, the blood level of Holstein Friesian cross, parity and stages of lactation on milk yield and composition.

Effects of season on milk yield and composition of dairy cows

The effects of season on milk yield and milk composition of dairy cows are presented. A significant mean difference (p<0.05) was observed in milk yield, percent of fat and protein due to season. Higher yield and percent fat were recorded during the dry season but for protein during the wet season. As a result of this study, the season didn't significantly affect milk percentage composition of total solid. Opposing this finding [14] reported that season didn't affect milk yield. a Similar finding was reported by that the overall mean for the fat content of milk was 4.53 percent which was almost similar (4.66) with this study [12]. Contrary to this also reported that TS content varied among seasons being highest in winter. In contrast to this study in the same location. Reported higher milk fat content from milk sampled from July to September. The same study also reported finding which agrees with this finding that Friesian crossbred dairy cows have shown high protein content in milk during the rainy season. Similar results were reported that fat content was significantly higher (3.97+0.24%) in the dry season than in the wet season (2.59+0.24%) whereas Casein (protein) content was higher in milk sampled in the wet season (3.27+0.06%) than in the dry season (2.88+0.06%). A similar study also reported that TS contents were not affected by the month of sampling. Similar results were reported that the milk protein level in the hot month was less than the wet season due to the decrease in the casein [13]. Contrary to this earlier study in the same location reported that milk total solids content of Boran-Friesian crossbred dairy cows was highest in July to September and the lowest in January to March [14].

Effects of genotype on milk yield and composition of dairy cows

The effects of genotype on milk yield and composition of dairy cows are presented. Milk yield of 62.5% and >75% crossbred cows were significantly higher than that of 50%

crossbred cows. Average monthly milk yield of cows of 50%, 62.5% and >75% crossbred was 215.59, 231.09 and 232.81 litters respectively, which differed significantly (p<0.05). Though there were no significant differences in milk components, milk protein of 62.5% crossbred cows was lower in figure than the other [15,16]. Finding agree with this study on milk yield that high merit cows had the highest yield of milk, whereas the low merit cows had the lowest yield of milk fat, protein, and lactose concentrations. Similar finding was reported that in the highland climatic zone, the mean MYL for cows with 50 percent B. Taurus genes was 2.6 times higher than that of the indigenous cows and cows with exotic inheritance of 75 percent B. Taurus genes showed almost a similar performance, with an MYL 2.7 times higher than that of local cows. A similar finding was reported Nantapo where milk yield and fat content of milk differ in different Genotypic. On contrary to this study [17,18]. Increasing the proportion of exotic genes in a cow leads to decreased milk component levels [19].

Effects of parity on milk yield and composition of dairy cows

The effects of parity on milk yield and composition of dairy cows. The difference in Parity of cow significantly (p<0.05) affected milk yield and protein content of milk. Significantly higher milk yield and protein content were recorded on dam parity five. An increasing trend observed in milk yield and protein content as dam parity advances. Similarly finding justified this, where an increase in milk yield with the increasing age was partially attributed to higher body weight, whereas the remaining 20% is the result of increased development of the udder during recurring pregnancies which results in larger mass of digestive system and mammary glands for synthesis of milk. Almost similar results were reported. Where mean lactation milk yield was found to be 2503.6 ± 76.8 litres (242.9 ± 2.6 l/month). In agreement with this study reported that parity significantly affected milk production where more milk in cows with greater parities than those with lesser parities [20,21]. In some research they reported finding in agreement with these results that there is an increase in milk yield towards 5th parity and decline thereafter.

Effects of stage of lactation on milk yield and composition of dairy cows

The Least Squares Means (LSM) of milk yield and composition of the different stages of lactation crossbred dairy cows in Holleta Agricultural Research Center of dairy farms is indicated in **Table 1**. Mean monthly milk yield was varied significantly (p<0.01) between different lactation stages. As lactation stage advanced there was decreasing in milk yield and increasing states of total solid% and protein. In agreement with this study reported the highest milk yield was observed in the early lactation stage while the lowest yield was recorded in the late stages of lactation. Although the fat percentage composition was not significantly affected by advancing lactation stages there is an increasing trend of figures [4]. A similar result was reported that record of highest milk yield in the early lactation stage and lowest yield in late lactation [22-26].

Table 1: LS mean ± SE monthly milk yield and composition of the different percent of exotic crossbred dairy cows in Holleta agricultural research center dairy farm.

Variables	N	Milk yield (months)	Fat%	Protein %	Total solid%
Season					
Wet season	219	223.68B ± 3.55	3.97B ± 0.11	3.95A ± 0.06	12.96 ± 0.07
Dry season	1055	229.32A ± 1.58	4.91A ± 0.09	3.56B ± 0.06	13.38 ± 0.13
Significance		*	*	*	NS
Genotype					
50% cross	1117	215.59B ± 1.57	4.36 ± 0.09	3.90 ± 0.05	12.94 ± 0.12
65.5% cross	115	231.09A ± 4.35	4.45 ± 0.12	3.44 ± 0.06	13.14 ± 0.11
≥ 75% cross	42	232.81A ± 4.09	4.51 ± 0.15	3.91 ± 0.11	13.42 ± 0.22
Significance		*	NS	NS	NS
Parity					
2	474	210.25B ± 2.38	4.29 ± 0.11	3.69B ± 0.04	13.07 ± 0.05
3	356	228.39A ± 2.79	4.50 ± 0.13	3.56B ± 0.04	13.09 ± 0.07
4	270	231.17A ± 3.06	4.38 ± 0.14	3.75B ± 0.06	12.94 ± 0.08
5	174	236.20A ± 3.26	4.59 ± 0.32	4.01A ± 0.31	13.57 ± 0.74
Significance		*	NS	*	NS
Lactation stage					
early	483	240.46A ± 2.18	4.33 ± 0.11	3.65B ± 0.04	12.90B ± 0.06
Mid	445	234.68B ± 2.41	4.28 ± 0.11	3.65B ± 0.04	12.95B ± 0.06
late	346	204.35C ± 2.65	4.71 ± 0.19	3.95A ± 0.16	13.65A ± 0.38
Significance		*	NS	*	*
Overall	1274	218.35 ± 1.45	4.62 ± 0.08	3.67 ± 0.05	13.01 ± 0.11

*: p<0.05 ;**: p<0.01; NS: Non significant; LS mean: Least Square Mean;

SE: Standard Error; Means: Same column with different subscript letters were significantly different

Similar results higher Milk yield in the early lactation stage then it decreased gradually until the end of lactation. Similarly for higher yield in early lactation but differently vise-versa for mid and late lactation in milk yield [27-29].

Interaction effect of seasons, genotype, parity and lactation stage on milk yield and composition of dairy cows

The mean squares of milk yield and composition of the interaction of season × breed (S × G),season × parity (S × P) , season × lactation stage (S × L), genotype × Parity (G × P),genotype × lactation (G × L), parity × lactation stage (P × L) crossbred dairy cows in Holleta agricultural research center of dairy farms is indicated in **Table 2**. Result of study showed that interaction of season with genotype and parity with lactation stage significantly influenced milk yield, the percentage composition of fat and total solid respectively. Milk yield negatively correlated with fat% (r=-0.537), protein% (r=-0.065), total solid (r=-0.053) [30,31]. Fat% significantly (p ≤ 0.0001) correlated with protein% (r=0.487) and total solid (r=0.531) **Table 3**. Protein% significantly (p ≤ 0.0001) correlated with Total solid (r=0.804). This implies that an increase in milk yield results in a decreasing percentage proportion of Fat%, Protein% and total solid% of milk [26]. This finding agrees with the finding of reported were milk yield negatively correlated with the percentage of fat, protein, lactose, SNF and milk composition strongly correlated with each other. This finding is supported by report of Anila and Muhammad that milk protein and fat percentages are inversely related to milk yield.

Table 2: Analysis of variance for the interaction of season × breed (S × G), season × parity (S×P), season × lactation stage (S × L), genotype × Parity (G × P), genotype × lactation (G × L), parity × lactation stage (P × L).

Mean squares					
Effect	**DF**	**Milk yield**	**Fat%**	**Protein**	**Total solid**
S × G	2	4915.58*	25.12*	0.33NS	14.48NS
S × P	3	1763.64NS	1.53NS	4.93NS	30.18NS
S × L	2	2236.86NS	2.92NS	2.11NS	17.92NS
G × P	6	2440.13NS	4.63NS	1.24NS	2.77NS
G × L	4	3602.16NS	5.59NS	0.91NS	4.36NS
P × L	6	3548.6NS	9.61NS	4.97NS	52.22*
Residual	1242	2301.14	7.28	2.85	14.31

*indicate statistical significance at the 0.05 probability levels, respectively; DF: Degrees of freedom; NS: Non-Significant

Table 3: Correlations coefficient among milk yield and composition.

	MY	**Fat%**	**Protein%**	**TS%**
MY	1			
Fat%	-0.537	1		
	0.057			
Protein%	-0.065(*)	0.487(***)	1	
	0.02	0.0001		
TS%	-0.053	0.531(***)	0.804(***)	1
	0.058	0.0001	0.0001	

*** Correlation is highly significant at the 0.0001 level (2-tailed); * Correlation is significant at the 0.05 level (2-tailed)

Conclusion

In overall from the findings, it can be concluded as milk yields of cows were significantly affected by season, exotic gene blood level, dam parity, and lactation stage. Season influenced Fat and protein percentage. Season, Parity and lactation stage significantly influenced milk protein percent whereas Fat% was more significantly affected by season. Milk yield and fat% significantly influenced due to the interaction of season with genotype whereas interaction of parity with the lactation stage significantly influenced percent for total solid of milk. Moreover, milk yield negatively correlated with the percentage of fat, protein, and TS. The percentage of fat positively correlated with the percentage of protein and Total solid and vise-versa.

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