Abstract W186

Genotype by Environment Interaction Effect on Lactation Pattern and Milk Production Traits in an Ethiopian Dairy Cattle Population

Gebregziabher Gebreyohannes*, Skorn Koonawootrittriron*, Mauricio A. Elzo† and Thanathip Suwanasopee[1]

*Department of Animal Science, Kasetsart University, Bangkok 10900, Thailand
†Department of Animal Sciences, University of Florida, Gainesville, FL 32611-0910, USA

SUMMARY

The objective of this study was to evaluate the effect of genotype by environment interaction (GEI) on lactation pattern and milk production traits in an Ethiopian multibreed dairy cattle population. The analyses used 4,488 lactation milk records of 1,320 cows born from 254 sires and 896 dams collected in two research centers (Bako and Holetta) from 1979 to 2010. Breeds present in the population were Horro, Boran, Friesian, Simmental and Jersey. Traits were lactation milk yield (**LY**), initial milk yield (**IY**), peak milk yield (**PY**), average milk yield per day (**YD**), lactation length (**LL**) and days to peak (**DP**). The effect of **GEI** was tested using a fixed linear model that considered herd-year-season, parity, environment (Bako and Holetta), breed and the interaction between breed and environment as fixed effects, and residual as a random effect. Lactation length was considered as a covariate for the analysis of **LY**. Least squares means (LSM) were compared among subclasses of each factor. All factors in the model affected **LY**, **IY**, **PY**, **YD** and **LL** (P < 0001). The effects of breed and breed by environment interaction on **DP** were not significant. All traits had significantly (P < 0001) higher LSM values in Holetta than Bako. *Friesian crossbred cows in Holetta had significantly higher LSM for LY (2111.9 ± 16.87 kg), IY (9.2 ± 0.08 kg), PY (11.6 ± 0.08 kg) and YD (6.6 ± 0.05 kg) than Simmental and Jersey crosses. The LSM for LY, PY and YD were significantly (P < 0.0001) higher for Friesian and Simmental than for Jersey crossbreds in Bako. However, the LSM IY and LL were not significantly (P > 0.05) different among Friesian, Simmental and Jersey crossbred cows. The LSM of LY, IY, PY, YD and LL for Boran and Horro were not different in both environments. In Holetta, the Jersey and Simmental were not significantly different for LY, IY, PY and YD. Thus, Friesian sires can be recommended for crossbreeding with Boran or Horro in Holetta, and Friesian, Simmental and Jersey sires in Bako.*

INTRODUCTION

Sustainable intensification of livestock production requires appropriate use of genetic resources with an understanding of the limitations and opportunities of the production environment in which the animals will be maintained. Tropical countries often rely on imported germplasm for crossbreeding purposes (Demeke *et al*., 2004). However, the climatic conditions, production systems, and markets are frequently different from those where the animals were evaluated. In countries like Ethiopia, with great diversity of agro-ecological conditions and livestock management practices, performance of genotypes may differ substantially across the range of available environments. In general, **GEI** arises when the performance of the different genotypes is not equally influenced by the different environments (Falconer and Mackay, 1996). The **GEI** that alters the ranking of series of genotypes between environments could considerably hamper selection. In these cases, the breeding goal should account for both traits and environments in which those traits would be expressed. *Thus, the objective of this study was to evaluate the effect of genotype by environment interaction on lactation pattern and milk production traits in Ethiopian dairy cattle from two geographical locations.*

MATERIALS AND METHODS

Geographical Locations and Climate Conditions. Milk records of individual dairy cattle were obtained from Bako and Holetta Agricultural Research Centers in Ethiopia. The Bako Agricultural Research Center is located 250 km West of Addis Ababa at an altitude of 1,650 m above sea level. The center received a mean annual rainfall of 1,200 mm in a bimodal distribution, 80 % of which fell from May to September. The area had a mean relative humidity of 59 % and monthly mean minimum and maximum temperatures of 13.5 and 27 ^{o}C, respectively, with an average monthly temperature of 21°C. The Holetta Agricultural Research Center is located 45 km west of Addis Ababa at elevation of 2,400 m above sea level. It is situated in the central highlands of Ethiopia. It has an average annual rainfall of approximately 1,200 mm. The annual average temperature is 18 °C and the average monthly relative humidity is 60 % (Gebreyohannes *et al*. 2013).

Four seasons were defined based on rainfall distribution and availability of grasses in the grazing fields: 1) June to August (main rainy season where ample feed for the herd in the grazing paddocks is available as green grass); 2) September to November (grazing conditions deteriorate and rainfall decreases in both frequency and intensity and finally stops; grazing condition supported by crop aftermath); 3) December to February (dry season, grazing paddocks dry and animals need supplementary feed); and 4) March to May (short rainy season, where light showers in March improve grazing conditions and availability of feed).

Feeding, Management, and Health Care. Herd feeding, management, breeding, and health care were described in previous reports for Holetta (Demeke *et al*., 2004) and Bako (Gebreyohannes *et al*., 2013). The feeding system at Bako was mainly based on grazing natural pastures (*Cynodon* spp and *Hyparrhenia* spp) for approximately eight hours (8 AM to 5 PM). Supplementation with hay (Rhodes grass (*Chloris gayana*) and natural pasture) or grass silage at night was practiced depending on the grazing conditions. Concentrate supplement was restricted to milking cows at the time of milking and pregnant cows during the last trimester of pregnancy. The concentrate mixture was composed of wheat bran (67%), noug (*Guizotia abyssinia*) seed cake (30%), bone meal (2%), salt and minerals (1%). Each kg of concentrate mixture provided 810.2 g of dry matter, 294.7 g of crude protein, 11.5 MJ of metabolizable energy and 717.5 g of digestible organic matter (Mesfin *et al*., 2003). All animals were routinely monitored for any health problems and annually vaccinated against common diseases (e.g., Blackleg, Anthrax, Foot and Mouth Disease, and Contagious Bovine Pleuropneumonia), and sprayed against external parasites.

Animals and Breeding. The breed groups represented in Bako and Holetta as sires and dams were: Horro (H), Boran (B), Friesian (F), Jersey (J), Simmental (S), (½ F × ½ H, ½ J × ½ H, ½ S × ½ H, ½ F × ½ B, ½ J × ½ B, ½ S × ½ B. Both centers used F, J, and S semen supplied from the National Artificial Insemination Center (NAIC). Crossbred and local H and B bulls selected from available males in each center were used for natural service. Purebred sires (H, B, F, J, and S) were mated to purebred indigenous dams (H and B) and to crossbred dams (½ F × ½ H, ½ J × ½ H, ½ S × ½ H, ½ F × ½ B, ½ J × ½ B, ½ S × ½ B). In addition, inter-se matings existed between sires and dams of the 6 crossbred groups. The semen was both imported and locally produced from purebred bulls by the NAIC. Mating took place throughout the year.

Figure 1. Agro-ecological diversity: 500 m (top left) to 4533 m (top right) above sea level) and a Horro cow and a Friesian × Horro bull

Data, Traits, and Statistical Analysis: The dataset consisted of lactation milk data from the Bako (from 1977 to 2010) and Holetta (from 1979 to 2010) research centers. The analysis used 4,488 lactation records of 1,320 cows born from 254 sires and 896 dams. The two centers had 74 sires in common.

The traits were actual lactation milk yield (LY; the total daily milk yield of the cow during the lactation period), initial milk yield (IY; the daily milk yield at the start of the lactation after the colostrum period), peak milk yield (PY; the highest milk yield recorded during the lactation), average daily milk yield (YD; average milk yield per day of lactation length), days to peak (DP; the period from calving to the date the peak daily milk is recorded) and lactation length (LL; the period the cow was milked in a lactation).

Breed group phenotypic means in two environments were compared using least squares means (LSM) from a fixed model. The model for IY, PY, YD, DP, and LL included the effects of herd-year-season (n = 248), parity (1 to 7 and above), environment (Bako and Holetta), breed group of cow (Horro, Boran, Friesian crossbreds with Boran and Horro, Jersey crossbreds with Boran and Horro, and Simmental crossbreds with Boran and Horro). The model for LY included all these effects plus LL as a covariate.

The expression of the same trait (LY, IY, PY and YD) in the two environments (Bako and Holetta) was considered to be two different traits. Thus, a bivariate mixed sire model was used to estimate variance-covariance components and to predict breeding values in Bako and Holetta. Fixed effects were year-season, parity, H, B, F, J, and S breed fraction of sire, H, B, F, J, and S breed fraction of dam, and general heterozygosity of cow. Random effects were sire additive genetic, permanent environment of their daughters, and residual. The general heterozygosity involved interbreed interactions between alleles of any two different breeds among the 5 breeds in the population. Estimated breeding values (EBV) for sires were obtained using Best Linear Unbiased Prediction (BLUP) procedures and computed with ASREML (Gilmour *et al*., 2009). Sires were ranked within each environment based on their EBV for each trait. Spearman's rank correlations between sire EBV in Bako and Holetta were estimated using PROC CORR (SAS, 2003).

RESULTS AND DISCUSSION

Lactation milk yield (LY), initial milk yield (IY), peak milk yield (PY) and average milk yield per day (YD) were significantly different (P < 0.001) among herd-year-season contemporary group (CG), parity, environment, cow breed group, and cow breed group × environment interaction (GEI) subclasses. Lactation length affected LY (P < 0.001). The significant effect of breed group on milk production traits observed in this study were likely due to large additive genetic differences between the introduced F, J, and S breeds and local H and B breeds as well as heterosis effects. The H and B cows had lower LY, IY, PY and YD and were milked for shorter periods of time compared to Friesian, Jersey and Simmental crossbred cows.

LSM. The herd in Holetta had higher LSM for LY (1,657.5 ± 27.18 vs. 1,428.2 ± 25.83 kg), IY (6.7 ± 0.13 vs. 4.5 ± 0.12 kg), PY (9.0 ± 0.13 vs. 6.7 ± 0.12 kg) and YD (4.8 ± 0.08 vs. 4.1 ± 0.08 kg) than the herd in Bako (P < 0.001) and shorter DP than the herd in Bako. First parity cows showed lower LY, IY, PY and YD but longer DP and LL (P < 0.001). Climatic conditions and herd management differed in Bako and Holetta. The herd in Bako was managed on grazing pastures throughout the year while that in Holetta was managed both on grazing pastures and indoor feeding. These environmental dissimilarities between Bako and Holetta affected the performance of F, J, and S crossbreds for at least one trait (**Table 1**).

Friesian crossbred cows in Holetta had higher (P < 0.001) LSM for LY, IY, PY and YD than Simmental and Jersey crosses in Holetta, and Friesian, Jersey and Simmental crosses in Bako. The LSM for LY, IY, PY and YD between the Jersey and Simmental crosses in Holetta were not different (P > 0.05). The LSM for LY, PY and YD for Simmental and Friesian crosses were higher (P < 0.0001) than the Jersey cross cows in Bako. However, the LSM for IY and LL were not different (P > 0.05) among the three exotic breeds in Bako. The Boran cows were not different (P > 0.05) from Horro cows in both Holetta and Bako for all traits (LY, IY, PY, YD and LL).

Additive Genetic and Sire EBV Correlations Across Environments. Additive genetic correlations between the two environments (i.e., Bako and Holetta) were 0.82 ± 0.32 for LY, 0.53 ± 0.39 for IY and 0.61 ± 0.33 for YD. Correlations between sire EBV rankings in Bako and Holetta were 0.86 for LY and IY and 0.87 for YD. Substantial re-ranking of sires occurred for LY, IY and YD across locations.

Sire re-ranking between Bako and Holetta is illustrated here with a group of sires that were represented at both locations. **Figure 2** shows the EBV and changes in ranking of the top 10 sires for LY that had daughters in both Bako and Holetta. These 10 sires accounted for 50% of the top 20 sires with the highest EBV for LY in each environment. Among these 10 sires in common across locations, 3 sires had higher ranking for LY in Bako than in Holetta, 4 sires had lower ranking for LY in Bako than in Holetta, and 3 sires had the same ranking in both locations.

In the absence of GEI, sires selected in either of the two environments could be used in both environments. Boettcher *et al*. (2003) recommended that when the level of GEI is too low there is no reason to justify a separate evaluation program for the different environments. However, the GEI in the present study resulted in re-ranking of sires in the two environments. Thus, genetic evaluation would require information from both Bako and Holetta, and selection of sires would need to be based on their EBV for LY at each location.

Table 1. Least squares means (± SE) for lactation pattern and milk production traits

	LY (kg)	IY (kg)	PY (kg)	YD (kg)	DP (d)	LL (d)
Bako – B	965.4 ± 106.38^{d}	2.1 ± 0.49^{e}	3.6 ± 0.51^{g}	2.3 ± 0.33^{e}	40.0 ± 5.03	234.7 ± 18.76^{c}
Bako – H	$1{,}172.7 \pm 33.97^{d}$	2.8 ± 0.15^{e}	4.6 ± 0.16^{fg}	2.7 ± 0.10^{e}	35.5 ± 1.56	222.9 ± 5.81^{c}
Bako – F	$1{,}703.1 \pm 25.06^{b}$	6.0 ± 0.12^{c}	8.6 ± 0.12^{c}	5.2 ± 0.08^{c}	40.8 ± 1.18	294.8 ± 4.41^{b}
Bako – J	$1{,}575.0 \pm 26.67^{c}$	5.5 ± 0.12^{cd}	7.8 ± 0.13^{d}	4.8 ± 0.08^{d}	41.1 ± 1.26	292.2 ± 4.69^{b}
Bako – S	$1{,}725.0 \pm 38.50^{b}$	6.0 ± 0.18^{c}	8.7 ± 0.18^{c}	5.4 ± 0.12^{bc}	44.7 ± 1.82	295.3 ± 6.79^{b}
Holetta – B	$1{,}369.7 \pm 76.75^{cd}$	4.7 ± 0.35^{d}	6.9 ± 0.37^{de}	3.5 ± 0.24^{e}	26.2 ± 3.61	215.1 ± 13.47^{c}
Holetta – H	$1{,}205.8 \pm 96.65^{d}$	4.1 ± 0.44^{de}	6.0 ± 0.46^{ef}	2.8 ± 0.30^{e}	36.2 ± 4.55	195.7 ± 16.98^{c}
Holetta – F	$2{,}111.9 \pm 16.88^{a}$	9.2 ± 0.08^{a}	11.6 ± 0.08^{a}	6.6 ± 0.05^{a}	27.9 ± 0.79	348.9 ± 2.96^{a}
Holetta – J	$1{,}793.1 \pm 22.91^{b}$	7.8 ± 0.11^{b}	9.9 ± 0.11^{b}	5.6 ± 0.07^{b}	27.7 ± 1.08	333.8 ± 4.05^{a}
Holetta – S	$1{,}807.0 \pm 34.17^{b}$	7.8 ± 0.16^{b}	10.3 ± 0.16^{b}	5.7 ± 0.11^{b}	30.3 ± 1.62	344.9 ± 6.03^{a}

[a, b, c, d] Least squares means within a column group with different letters differ significantly (P < 0.001).
LY = Lactation milk yield; IY = Initial milk yield; PY = Peak milk yield; YD = average yield per day; DP = Days to peak and LL = Lactation length.
B = Boran; H = Horro; F = Friesian, J = Jersey, and S = Simmental.

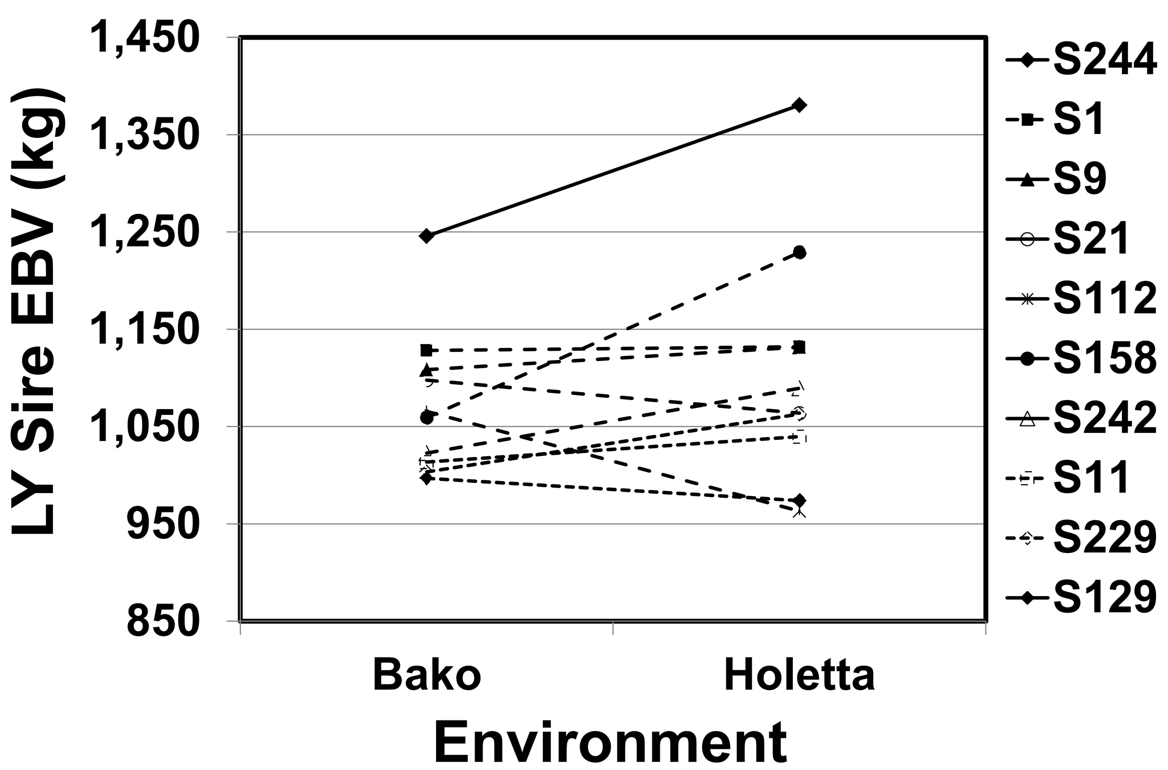

Figure 2. Estimated breeding values of the top 10 sires for lactation milk yield (LY, kg) in Bako and Holetta

FINAL REMARKS

Significant differences among breed group means in Bako and Holetta suggested that they expressed their milk yield production potential differently in these two locations. Low genetic correlations between dairy traits measured in Bako and Holetta as well as Spearman's rank correlations between sire predicted breeding values across locations suggested that genetic evaluation and selection of sires would require information from both locations to accurately select the most appropriate sires in each environment.

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