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Milk Production and Body Weight Change of Cross-Bred Dairy Cows as Affected by Walking Distance and Breed Variations

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Abstract
The study was conducted in Bako Agricultural Research Centre, in Western Ethiopia with objectives of assessing the impact of breed and walking distance on milk production. Two breeds of dairy cows (50% Horro X 50% Friesian= HF and 50% Horro X 50% Jersey= HJ) were used to conduct this experiment. The cows were assigned to three walking distance groups: WD0= grazing around the barn, WD1.5= grazing 1.5km away from the barn and WD3.0= grazing 3km away from the barn. The experiment was arranged as a 2 x 3 factorial in RCBD. A total of 36 cows uniform in previous lactation milk yield and at mid stage of lactation were involved in the study, and they were grouped into two based on the period of joining the experiment. The result showed that the mean daily milk yield of cows was higher ($p<0.05$) for WD0 cows than WD3.0, while milk yield of WD1.5 cows was not different from WD0 or WD3.0. The mean protein content of milk from HF cows (27.03 g/kg) was significantly higher ($p<0.05$) than HJ cows (25.2 g/kg). The mean milk protein content of cows in WD1.5 (27.8 g/kg) was significantly ($p<0.05$) higher than those inWD0 and WD3.0. The mean milk fat composition of HJ cows (57.7 g/kg) was significantly ($p<0.05$) higher than HF cows (51.0 g/kg). HF cows lost weight while HJ gained during the experimental period. Dairy cows in WD0 had higher mean body weight and better gain compared to those walked 1.5 and 3.0 km. This study further demonstrated that the loss of BW at longer distance of 3.0 km was higher for HF (-4.1 kg) compared to HJ (-1.0 kg) cows.
Keywords: Horro cows; walking distance; milk yield; cross-bred dairy cows

Introduction

Dairy production is an important component of livestock production system in Ethiopia. Dairy production depends mainly on cattle followed by camels, goats and sheep. In Ethiopia, milk production is dominated by smallholder farmers. The total volume of raw milk produced varied from 0.9 million tons in 2000 to 1.3 million tons in 2008. However, the current level of cattle productivity in Ethiopia is one of the lowest in the world. The Milk yields in Ethiopia are also very low and estimated to be at 210kg/year/cow, a level less than half that of the Kenyan milk yield of 550kg/year/cow (Negassa *et al*., 2011).

Crossbreeding of indigenous cattle with improved exotic genotype has been recommended and being implemented in Ethiopia for over the last 50 years in order to improve milk production. Consequently, crossbreds have been produced and distributed to farmers in different parts of the country. However, even though efforts were made to evaluate crossbreds before distribution to farmers, there was no much attention paid to look into the response under extensive husbandry in tropics when they are forced to walk long distance for grazing.

Thus, it is important to have a totally integrated production package that balances all aspects of the production system. The genotype and its management must be matched to climatic conditions that exist and available nutrition. Under extensive grazing systems, the energy cost for grazing is greater as the animals spend more time eating and walking. The situation is exacerbated for dairy cows as it comprises energy required for milk production.

Depending on management conditions, dairy cows are required to walk more or less long distances under smallholder farmers' management for grazing. When walking is restricted (1 to 3 km/day), animal performances are generally not affected (Gustafson *et al*, 1993).

In case of Bako Agricultural Research Center's dairy farm, the distance to and from grazing field ranges from 3-6 km per day, excluding the distance covered while grazing. Currently, the center is distributing 50% crossbred heifers to farmers based on a recommendation by Ministry of Agriculture. However, no work has been done to document the response of these animals to walking long distances for grazing and to environmental stresses. Though, such negative impacts and physiological responses are less manifested in Zebu cattle breeds, there are reports showing a significant decrease in milk production of Holstein and Jersey dairy cows (Farooq *et al*., 2010; Van Hes, 1974).

Experience of introducing high producing breeds in the rural communities of our country, where the animals are managed under extensive grazing condition is with little or no consideration of the requirements for production, maintenance (activities and body processes). Therefore, this study was intended with the objective of assessing the impact of walking distance and breed variation on milk production and body weight change in crossbred dairy cows in the study site.

MATERIALS AND METHODS

The study was conducted in Bako Agricultural Research Center, in Western part of Ethiopia. The center is found 9.133^{O} N and 37.050^{O} E. The area receives an annual average rainfall of 1220 mm with mean minimum and maximum temperature of 14^{O}C and 28^{O}C, respectively. The area is characterized by a sub-humid and hot climate with an altitude of 1650 masl.

Thirty-six multi-parous crossbred (50% Horro + 50% Friesian and 50% Horro + 50% Jersey) dairy cows have been used for this study from dairy farm of Bako research center. The number of lactating cows used from each breed was 18 and they were found in mid stage of lactation (3rd to 6th month after calving). Animals were allowed to graze for equal period of time irrespective of the treatment imposition. Individual cows have been offered concentrate and corn silage in the morning and during the night while milked. The amount of concentrate feed offered was based on average milk yield of cows so that each cow received 0.5 kg of concentrate per kg of milk produced per day following the feeding practice of the farm. Equal amounts (1.5 kg/day) of corn silage were offered for each lactating cow. All the animals had free access to drinking water. The experimental animals were kept in open shade at night, which is the common practice for all animals in the Research Center.

The experiment was laid down as a 2 × 3 factorial arrangement with two levels of breed (50% Horro + 50% Friesian; 50% Horro + 50% Jersey) and three levels of walking distance (Grazing around the barn, Grazing 1.5 km and 3 km away from the barn) in a randomized complete block design (RCBD). (Note: HF= 50% Horro + 50% Friesian and HJ= 50% Horro + 50% Jersey).

With regard to the design of the experiment, due to shortage of uniform crossbred lactating cows at mid stage of lactation at a time, the experiment employed two different periods. Accordingly, eighteen lactating cows (nine cows of each breed) were assigned to treatments during the first period, while the remaining 18 were also assigned to the same treatments during the second period. Thus, period of joining the experiment was used as blocking factor. In each period (block) the cows were stratified into three categories based on their initial weekly milk yield in ascending order. This was done separately for both breeds and each category consisted of three cows. Then from each category cows were randomly assigned to the three walking distance using a random number. This was repeated until each walking distance receives equal number of cows from the three categories. Each experimental period lasted 14 weeks. However, the first week was left as period of acclimatization and only thirteen weeks data has been considered for analysis.

All cows were milked twice a day at 7:00 AM (morning) and 6:30 PM (evening). The milk yield was measured and recorded at each milking for individual animals throughout the experimental period. The milk yield was recorded for thirteen weeks. Milk sample was collected from both AM and PM yield weekly and 100 ml was sampled in a bottle, preserved with one drop of 5% potassium dichromate solution per each bottle and stored in a refrigerator at 4^{o}C. Immediate after the end of the experiment, milk samples were pooled per animal and delivered to the laboratory for analysis of chemical constituents.

Body weights of all cows were measured at the beginning of the experiment, every two weeks (except the last two measurements which were taken in a week difference) and at the end of the experiment using weighing bridge. Each weighing was done in the morning before feeding. Including the initial and final body weights a total of eight measurements were taken for each cows.

Statistical Analysis: Data on milk production, milk composition, body weight and physiological parameters (heart rate, body temperature and respiration rate) of the cows were analyzed as 2 × 3 factorial arrangement in Randomized Complete Block Design (RCBD) using Two-way ANOVA procedure. The statistical model used was:

$$y_{ijk} = \mu + D_i + B_j + (D \times B)_{ij} + P_k + e_{ijk},$$

where, μ= overall mean of observations,

D_i = effect of ith walking distance,

B_j = effect of jth breed,

$(D \times B)_{ij}$ = effect of interaction between ith walking distance and jth breed,

P_k = effect of kth period of joining the experiment

e_{ijk} = residual.

Mean differences between treatment means and subjects under study were tested by least significant difference (LSD) method.

RESULTS

Milk yield: The mean daily and weekly milk yield of cows showed that the interaction between breed and walking distance was not significant ($p>0.05$) (Table 4). The main effect of breed had also a non significant effect on daily and weekly milk yield of the cows. Similarly, blocking (period of joining the experiment) effect was not significant. However, walking distance had shown a significant ($P<0.05$) effect on both daily and weekly milk yield of the cows.

Though the results were not statistically significant (p>0.05), the least squares means of breed*walking distance interactions showed that HF0 cows (HF cows that walked 0km away from the barn) had slightly higher mean daily milk yield followed by HJ0 cows while HJ3.0 and HF3.0 cows had the least mean daily milk yield.

Table 1. Mean daily and weekly milk yield (±SE) of dairy cows at Bako Agricultural Research Center during mid-stage of lactation (kg)

Variables	Mean daily milk yield (± SE)	Mean weekly milk yield (± SE)
Breed		
HF	4.26 ± 1.33	31.6 ± 3.9
HJ	4.15 ± 1.05	29.5 ± 3.2
Walking distance (km)		
0	5.04^{a} ± 1.23	35.2^{a} ± 3.5
1.5	3.91^{ab}± 1.14	32.2^{ab} ± 3.8
3.0	3.67^{b} ± 1.13	24.2^{b} ± 3.1
Breed*Walking distance		
HF0	5.14 ± 1.42	36.2 ± 3.9
HF1.5	3.97 ± 1.26	33.6 ± 4.2
HF3.0	3.68 ± 1.27	25.0 ± 3.6
HJ0	4.95 ± 0.98	34.3 ± 3.1
HJ1.5	3.84 ± 1.02	30.8 ± 3.6
HJ3.0	3.65 ± 1.00	23.4 ± 2.4

$^{a-b}$ means with the same superscripts for the same effect in the same column are not significantly different (p>0.05)

Milk composition: Milk composition of dairy cows (HF; HJ) is presented in Table 5. The interaction between breed and walking distance was not different (p>0.05) for milk protein content in the current study. However, there was a significant variation in mean milk protein content between the two breeds (p<0.05).

Table 2. Mean **(±SE)** milk composition of dairy cows (g/kg of milk) in Bako Agricultural Research Center

Variables	Protein Mean (±SE)	Fat Mean (±SE)	Total solid Mean (±SE)
Breed			
HF	27.03^{a} ± 3.4	51.08^{a} ± 4.5	156.31 ± 8.7
HJ	25.24^{b} ± 2.1	57.72^{b} ± 4.6	148.98 ± 35.4
Walking distance (km)			
0	25.25^{b} ± 2.5	55.37 ± 5.0	158.18 ± 11.4
1.5	27.76^{a} ± 3.2	55.04 ± 5.1	156.67 ± 11.1
3.0	25.40^{ab} ± 2.7	52.79 ± 6.7	155.54 ± 41.1
Breed*Walking distance			
HF0	24.72 ± 3.1	52.4^{ab} ± 5.3	162.83 ± 9.8
HF1.5	30.02 ± 2.3	50.9^{b} ± 5.2	151.92 ± 4.3
HF3.0	26.35 ± 2.9	49.9^{b} ± 3.2	159.17 ± 7.9
HJ0	25.78 ± 1.8	58.3^{ab} ± 2.4	153.50 ± 13.2
HJ1.5	25.50 ± 2.2	54.6^{ab} ± 4.6	134.27 ± 14.2
HJ3.0	24.45 ± 2.4	60.1^{a} ± 5.1	162.83 ± 58.9

$^{a-b}$ means with the same superscripts for the same effect in the same column are not significantly different (p>0.05)

Body Weight Change: Body weight of dairy cows was not influenced (p>0.05) by the interaction of breed and walking distance (Table 7). However, the Analysis of Variance showed that there was a strongly significant (p<0.0001) variation in mean body weights of cows due to the main effect breed. Thus, HF cows were heavier compared to HJ cows. The effect of experimental period (block) was significant in adjusting body weight change (p= 0.0217).

Table 3. Mean body weight (kg) of dairy cows that were under study at Bako Agricultural Research Center

Variables	Initial BW (Mean ± SE)	Mean BW (Mean ± SE)	Final BW (Mean ± SE)	Total BW change (kg)
Breed				
HF	$277.5^{a} \pm 1.90$	$272.1^{a} \pm 2.00$	$266.6^{a} \pm 2.43$	-10.9
HJ	$246.2^{b} \pm 2.21$	$254.8^{b} \pm 2.23$	$263.3^{b} \pm 2.39$	+17.1
Walking distance (km)				
0	263.3 ± 4.05	$266.5^{a} \pm 4.13$	$269.6^{a} \pm 4.17$	+6.3
1.5	261.3 ± 4.15	$262.8^{b} \pm 4.10$	$264.3^{b} \pm 4.07$	+3.0
3.0	261.3 ± 4.11	$261.1^{b} \pm 4.00$	$260.8^{b} \pm 3.95$	-0.5
Breed*Walking distance				
HF0	276.8 ± 1.70	281.3 ± 1.92	285.8 ± 2.07	+9.0
HF1.5	276.7 ± 2.30	278.2 ± 2.05	279.6 ± 2.09	+2.9
HF3.0	278.8 ± 1.52	276.8 ± 1.42	274.7 ± 1.67	-4.1
HJ0	245.7 ± 1.95	249.8 ± 1.90	253.8 ± 1.97	+8.1
HJ1.5	244.8 ± 1.79	246.8 ± 1.84	248.8 ± 1.84	+4.0
HJ3.0	247.8 ± 2.65	247.3 ± 2.68	246.8 ± 2.76	-1.0

[a-b] means with the same superscripts for the same effect in the same column are not significantly different ($p>0.05$)

DISCUSSION

Similarly, even though it turned out to be non significant, mean weekly milk yield was slightly higher for HF cows compared to HJ cows, which might be attributed to breed difference. Chernet *et al*. (2000) reported average lactation yields of the 50% crosses of Horro with Friesian or Jersey under on station controlled management to be 1355.0 and 1375.4 kg, respectively, with corresponding lactation lengths of 293 and 294 days.

The results on daily milk yield of the three walking distances showed that the mean daily milk yield of cows was higher ($p<0.05$) for WD0 cows than WD3.0, while milk yield of WD1.5 cows was not different from WD0 or WD3.0. This shows that the more the cows walk, the less the milk yield will be. The finding was consistent with the results of Juarez *et al*. (2003), who reported a decrease in milk yield of Holstein cows with increased walking distance.

Currently, there are no documented works in our country on how the Holstein and Jersey cows or their crosses respond to extreme walking and how their milk production is affected. The finding of this study therefore, demonstrated that walking long distance for grazing under extensive husbandry has negative effect on milk yield.

Zerbini and Alemu (1999) in their study on lactating crossbred cows subjected to work, have also reported that there was a significant reduction in milk yield of working cows than non-working. However, in this study no significant variation in the response of milk yield to walking was observed between the two breeds considered (HF and HJ). Thus, this study cannot propose a difference in energy balance (during the days of walking) between the two breeds. Rather, a smaller decrease in milk yield of HJ cows than HF cows was observed for the same distance walked. This disparity could be due to morphological differences which allow HJ cows to expend less energy while walking; their weight is slightly below that of HF, but it cannot be concluded that live-weight difference was responsible for the variation of milk yield response to walking. Instead it is possible to say that HJ cows are able to better counteract a considerable energy shock.

The mean milk protein content of HF cows (27.0 g/kg) was significantly higher ($p<0.05$) than that of HJ cows (25.2 g/kg). There was also a significant variation ($p<0.05$) in mean milk protein content of cows at different walking distance. Thus, the mean milk protein content was significantly higher ($p<0.05$) for WD3.0 than WD0. However, there was no variation in mean milk protein content between cows in WD0 and WD3.0. Earlier study made by Coulon *et al* (1998) reported a higher milk protein content of cows that walked 9.6km/day than those kept in barn. This result is consistent with the findings of the present study in which cows in WD1.5 and WD3.0 had a higher mean milk protein than those in WD0. Similarly, Aharoni *et al*. (2009) reported a higher milk protein percentage in grazing cows compared with cows kept in barn.

There was a significant ($p<0.05$) variation in milk fat content between the six treatment groups (i.e., interaction effect). The result shows that the mean milk fat composition of cows in HJ3.0 was highest ($p<0.05$) while it was the lowest for cows in HF3.0 and HF1.5 groups. However, milk fat composition of cows in other groups was moderate and similar ($p>0.05$) across the treatment groups. This shows that walking results in mobilization of body fat. Consistent with the results of the current study, Pedernera *et al*. (2008) related higher milk fat content of walking cows with higher milk acetone concentration, which is an indicator used to assess the mobilization of body fat. The milk fat composition was also significantly affected by breeds ($p<0.05$), where it was higher for HJ cows (57.7 g/kg) than HF cows (51.0 g/kg). Blocking had no significant effect on the mean milk fat composition ($p>0.05$). According to Hurley (1997), the composition of milk differs between breeds;

Jersey and Guernsey breeds give milk of higher fat content than Shorthorns and Friesians (i.e., consistent with the results of the current study) and Zebu cows can give milk containing up to 7% fat. This author also reported a wide variation in milk fat content between different breeds than other milk constituents. There was no difference (p>0.05) in mean milk fat content of cows that were in the three walking distance groups. However, the mean milk fat content of cows in WD3.0 (55.4g/kg) was slightly lower compared to cows in WD0 and WD1.5, though it was not significant (p>0.05).

Consistent with the current study, Juarez *et al*. (2003) reported that, Holstein cows with increased walking have experienced a reduction in milk fat composition. However, contrary to the present study, Coulon *et al* (1998), on their study on two dairy cattle breeds of France (Montbeliarde and Tarentaise), reported a higher fat content of milk from cows that walked 9.6km/day than those kept in barn. Similarly, contrary to the results of this study, Kolb (1987) reported an increase in fat content of milk as a result of reduced milk yield. The variations in fat content were linked to the concentration of the fat yielded, which might be attributed to fluctuations in feed supply (Stobbs and Brett, 1974). The animal mobilizes its body reserves to synthesize milk fats which are concentrated in a smaller volume.

This study showed that there was no significant (p>0.05) difference in mean total solid content of milk across the different breeds and walking distance compared. Though the results were not statistically significant (p>0.05), the mean total solids content of milk from HJ cows (148.9 g/kg) was slightly lower than HF cows (156.3 g/kg). However, the mean total solid content of milk of cows in the group WD0 (158.2 g/kg) was slightly higher than the other walking distance groups.

Similarly, there was a significant variation in body weight change of cows assigned to different walking distances (p<0.05). Total body weight change calculated as the difference between the final and initial body weight was presented in Table 7. The result showed that HF cows lost weight while HJ gained during the experimental period. Dairy cows in WD0 had higher mean body weight and better gain compared to those walked 1.5 and 3.0 km. Thus, for cows that were in WD3.0, the total live weight changes was 6kg, but this value reduced to 3 kg for cows walked 1.5 km (WD1.5) and a loss of 0.5 kg was recorded for cows walked 3 km (WD3.0). This study further demonstrated that the loss of BW at longer distance of 3.0 km was higher for HF (-4.1 kg) compared to HJ (-1.0 kg) cows. Coulon *et al* (1998) also reported 40 kg lower live weight of cows that walked than the others remained at the barn for the two breeds of dairy cows in France. Though their result agrees the findings of the current study, the high magnitude of weight loss could be attributed to variation in breed, distance of walking or climatic condition.

This experiment has clearly confirmed that a long walk incurs a considerable decrease in milk yield. The overall findings of this experiment depict that the response of milk yield to walking differed between HF and HJ cows. However, due to the fact that there was no significant variation in the response of milk yield to walking between the two breeds, this study cannot propose a difference in energy balance (during the days of walking) between the two breeds. Rather, a smaller decrease in milk yield of HJ than HF cows was observed for the same distance walked. However, the practical consequences of these results (drop in milk yield varying according to breed) can be considerable, particularly in cows managed under an extensive system where walking might be longer than those considered in this experiment. Walking had resulted in live-weight loss of cows. And the decrease in live-weight was considerably different between the two breeds as HF cows lost much weight than HJ cows for the same distance walked.

REFERENCES

Chernet A, Gebregziabher G, Gizaw K, Mulugeta K, Alganesh T (2000). Reproductive performance and lactation yield of F1 (B. indicus x B. Taurus) crossbred cattle at Bako. Pp. 386-396. In: Proceedings of the seventh Annual Conference of Ethiopian Society of Animal Production (ESAP) Addis Ababa, Ethiopia, 26-27 May 1999.

Coulon JB, Pradel P, Cochard T, Poutrel B (1998). Effect of extreme walking conditions for dairy cows on milk yield, chemical composition and somatic cell count. J. Dairy Sci. 81: 994-1003.

Farooq U, Samad HA, Shehzad F Qayyum A (2010). Physiological Responses of Cattle to Heat Stress. Wor. Appl. Sci. J. 8: 38-43.

Gustafson GM, Luthman J, Burstedt E (1993). Effect of daily exercise on performance, feed efficiency and energy balance of tied dairy cows. Acta. Agric. Scand. 43:219–227.

Juarez ST, Robinson PH, DePeters EJ, Price EO (2003). Impact of lameness on behavior and productivity of lactating Holstein cows. Appl. Anim. Behav. Sci. 83:1-14.

Negassa A, Rashid S and Gebremedhin B (2011). Livestock Production and Marketing. Ethiopia Strategy Support Program II (ESSP II) Working Paper 26. IFPRI-Addis Ababa, Ethiopia.

Van Hes AJ (1974). Energy intake and requirements of cows during the whole year. Liv. Prod. Sci. 1: 21–32.

Zerbini E, Alemu G (1999). Effect of work applied at different stages of lactation on milk production, reproduction and live-weight change of F1 crossbred dairy cows used for draught. Anim. Sci. 69: 473-480.