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Productive performance of indigenous and HF crossbred dairy cows in Gondar, Ethiopia

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Abstract

Aim: To study the magnitude of variation in lactation length (LL), lactation milk yield (LMY) and peak-yield (PY)due to genetic and non-genetic cases in indigenous and crossbred cattle reared under private dairy unit in and around Gondar, Ethiopia.

Materials and Methods: The study was conducted on 411 milch animals from 86 dairy farmers comprising of 172 indigenous and 239 Holstein-Friesian (HF) crossbred cows. These cows were maintained under farmer's management system in and around Gondar (Ethiopia) and were analyzed by Least squares analysis to study the magnitude of variation in their LL, LMY and PY due to genetic and some non-genetic factors.

Result: The overall Least squares means for LL, LMY and PY were estimated to be 275.1165.23 days, 1407.3471.34 litres and 6.880.38 litres respectively. Genetic group and lactation order had significant effect (P0.01) on LL, LMY and PY. Season of calving had significant effect (P0.01) on LMY and PY but its effect on LL was non-significant. Effect of location of herd was significant (P0.05) on LMY and PY while its effect on LL was non-significant. Variations in all the traits due to herd size and farming system were statistically non-significant.

Conclusion: Productive performance of dairy cows in this study was found to be lesser than the optimum values desirable for profitable milk production.

Keywords: crossbred cows, indigenous, lactation length, lactation milk yield, peak milk yield.

Introduction

Ethiopia is believed to have the largest livestock population in Africa, and dairy production is an important component of livestock farming in Ethiopia. The country has about 27 breeds of cattle [1]. The total cattle population for the country is estimated to be about 53.99 million. Out of this total cattle population, the female cattle constitute about 55.48 percent [2]. The huge and diverse cattle population, varied and favorable agro-ecology for dairying, increasing demand for dairy products in urban and peri-urban areas, long-standing culture of dairy products consumption, and favorable policies are indicators of the importance and potential of dairying in the country [3]. However, productivity of dairy animals in general is limited. About 98.95 percent of the total cattle in the country are local breeds [2] and their production potential is very low. In 2009, the average cow milk production was estimated to be only 1.54 litres/cow/day [4], and the per capita milk consumption was only about 16 kg/year, which is much lower than African and world per capita averages of 27 kg/year and 100 kg/year, respectively [5].

Although a little improvement is noted in recent report indicated that the total production of cow milk is about 4.06 billion litres, this only translates to an average daily milk production/cow of 1.86 litres/day [6]. Some improvement is also reported in the per capita consumption of milk and estimated it at 19.2 kg [7]. Further, the annual rate of increase in milk yield (estimated to be 1.2%) lags behind the increment in human population (estimated to be about 2.7% per annum) [8] and this resulted in large supply–demand gap for fresh milk [9]. To meet the ever-increasing demand for milk and milk products, genetic improvement of the indigenous cattle has been proposed as one of the options. Genetic improvement of the indigenous cattle, basically focusing on crossbreeding, has been practiced in many developing countries.

In Ethiopia, crossbred cattle which are mainly cross of zebu with Holstein- Friesian cattle have been used for milk production for decades. An accurate evaluation of the performance of crossbreds as well as indigenous cows is critical to the development of appropriate breeding strategies. The success of dairy production in general and crossbreeding programmes in particular needs to be monitored regularly by assessing the productive performance under the existing management system. However, information is limited about the productive performance of dairy cows in smallholder urban and peri-urban dairy farms in the tropics, particularly in Ethiopia [10]. Lactation period (LL), lactation milk yield (LMY) as well as peak milk yield (PMY) of a milch animals are the important production parameters of their economic worth. Thus, the present investigation was undertaken to study the effect of genetic and non-genetic factors on LL, LMY and PY in indigenous as well as crossbred cattle maintained in small dairy units under farmer's management located in and around Gondar (Ethiopia).

Materials and Methods

Study area: The study was conducted in and 10 km around Gondar city, Amhara National Regional State, located in the northwestern part of Ethiopia. Study area is located between 700 and 778kms northwest of the capital, Addis Ababa. The study zone is located between geographical coordinates 12.3º to 13.38º north latitudes and 35.5º to 38.3º east longitudes and the altitude ranges from 550 to 4620 meters above sea level in western lowland and in north Semen Mountain, respectively. The average annual rain fall varies from 880mm to 1772 mm, which is characterized by a monomodal type of distribution. The mean annual minimum and maximum temperatures are 10ºC in the highland and 44.5ºC in the lowland [11].

Study population and sampling procedure: A total of 411 milch animals comprising of 172 indigenous and 239 HF crossbred cows from 86 smallholder dairy farmers in and around Gondar city of Ethiopia were included in this study. Farmers were interviewed randomly with scheduled questionnaire which was mainly based on the productive performance information of Indigenous and HF crossbred dairy cows. The questionnaire was developed in accordance with the objectives of the study and was designed in a simple manner to get accurate information from the dairy farm owners. Each respondent was given a brief description about the nature and purpose of the study.

The entire study area was divided into two zones *viz.* urban which constitute the city area and peri-urban constitute in a radius of about 10 km around the city. The private dairy units were grouped into three groups based on the number of milch animals they possessed and delineated as herds of sizes up to 3, 4-6 and 7 and above. To study the influence of season of calving on different economic traits, the year was divided into three seasons viz. Hot-dry (March-June), Hot-humid (July-October) and Cold (November-February). Performance records of milch animals in first to fifth lactation were only included. On the basis of the farming system adopted by the farmers, the units were classified into two types i.e. household exclusive practicing animal husbandry and those practicing animal husbandry integrated with crop-production. Lactation length (LL), lactation milk yield (LMY) and peak yield (PY) were the economic traits taken as the measures of production efficiency in this study. Stratified random sampling with proportional allocation [12] was adopted for selection of respondent units.

Statistical analysis: Data collected were subjected to Least squares anµalysis [13] for which the following mathematical model was utilized:

$$Y_{ijklmnp} = + G_i + Z_j + F_k + HS_1 + S_m + P_n + e_{ijklmnp}$$

Where,

$Y_{ijklmnp}$ = the value of p^{th} individual under i^{th} genetic group, j^{th} zone, k^{th} farming system, 1^{th} herd size, m^{th} season of calving and n^{th} parity.

µ = the population mean.

G_i = the effect of i^{th} genetic group (i=1, 2)

Z_j = the effect of j^{th} location herd (j=1, 2)

F_k = the effect of k^{th} farming system (k=1, 2)

Hs_1 = the effect of l^{th} herd size (1=1, 2, 3)

S_m = the effect of m^{th} season of calving (m=1, 2, 3)

P_n = the effect of n^{th} parity (n=1, 2, 3, 4, 5)

$e_{ijklmnp}$ = the random error associated with individual which is randomly and independently distributed with mean zero and variance $?^2$.

The statistical significance of various effects was tested by "F" test. Whereas, the "F" value was significant, the Duncan's Multiple Range (DMR) Test modified by Kramer [14] was utilized for pair wise comparison of the Least square means at 5 and 1 percent level of probability.

Results

Lactation length: The overall Least squares means for LL in indigenous and HF crossbred cows included in this study were estimated to be 275.11±65.23 days (Table-2). Genetic group had significant (P≤0.01) influence on LL, its contribution to the total variation in the trait being 57.23 % (Table-1). The HF crossbred cows had significantly higher average LL (325.12±61.28 days) than that of indigenous dairy cows (204.33±70.35 days). The effect of zone, herd-size and season of calving on LL was statistically not significant (Table-1). Lactation order (parity) effect contributed significantly (P 0.01) to the total variation in LL and the magnitude of contribution being 6.14 % (Table-1). The mean LL was longer in the fourth calvers (285.48±78.12days) followed by third (282.2861.98 days), second (279.50±65.56 days), first (276.61±58.34 days) and fifth (255.16±55.04 days) calvers (Table-2). The farming system did not have any significant influence on LL.

Lactation milk yield: The overall Least squares means for LMY in indigenous and HF crossbreed cows, included in this study were estimated to be 1407.34 ±71.34 days (Table-2). Genetic group had significant (P≤0.01) influence on LMY, its contribution to the total variation in the trait being 91.81%. HF crossbred cows had the significantly higher average LMY (2123.43 ±65.67 litres) than that of indigenous cows (403.21± 90.34 litres). Variation in zone had also significant (P0.05) influence LMY (Table-1). The urban zone of study area had significantly higher average LMY (1464.65±78.34 litres) than that of peri-urban zone (1352.12±69.87 litres). The effect of herd-size on LMY was statistically not significant (Table-1).

Table-1. Least square analysis of variance showing effects of genetic and non-genetic factors on lactation length, lactation milk yield and peak yield of animals in and around Gondar (Ethiopia).

Sources of variation	d.f.	Lactation length M.S.S. (R^2)	Lactation milk yield M.S.S. (R^2)	Peak yield M.S.S. (R^2)
Genetic group	1	22676.39** (57.23)	28973865.34** (91.81)	704.65** (85.21)
Zone	1	238.36 (0.77)	33023.03* (0.21)	3.34* (0.23)
Herd-size	2	164.54 (0.58)	23134.51 (0.14)	1.66 (0.17)
Season of calving	2	183.27 (0.62)	28996.34** (1.91)	17.87** (1.48)
Lactation order	4	538.35** (6.14)	498881.39** (4.11)	37.75** (7.02)
Farming system	1	11.14 (0.02)	1748.32 (0.03)	0.02 (0.00)
Residual	399	99.87 (34.64)	10241.62 (1.79)	0.59 (5.89)

** $P \leq 0.01$, * $P \leq 0.05$. Figure mentioned in parenthesis indicates R^2 value. d.f.: degree of freedom, M.S.S.: mean sum of squares

Table-2. Least square means lactation length, lactation milk yield and peak yield under genetic and non-genetic factors in animals in and around Gondar (Ethiopia).

Sources of variation	Lactation length (days) Mean±S.E	Lactation milk yield (litres) Mean±S.E	Peak yield (litres) Mean±S.E
Overall mean	275.11±65.23	1407.34±71.34	6.88±0.38
Genetic Groups			
Indigenous cow	204.33±70.35[a]	403.21±90.34[a]	2.54±0.41[a]
HF crossbred	325.12±61.28[b]	2123.43±65.67[b]	9.87±0.29[b]
Zones			
Urban	281.61±68.22	1464.65±78.34[a]	7.34±0.35[a]
Peri-urban	271.58±60.32	1352.12±69.87[b]	6.54±0.44[b]
Herd-sizes			
(Up to 3) animals	278.34±39.24	1398.23±91.56	6.76±0.29
(4-6) animals	274.54±74.23	1418.81±56.45	7.02±0.37
(7 & above) animals	273.88±73.12	1406.80±78.76	6.75±0.44
Seasons of calving			
Mar. – June	275.15±51.36	1364.23±84.32[a]	6.59±0.31[a]
July – Oct.	277.43±76.22	1482.05±68.90[b]	7.42±0.37[b]
Nov. – Feb.	274.86±62.45	1376.39±74.50[a]	6.63±0.43[a]
Parities			
1st	276.61±58.34[a]	1320.26±49.97[a]	6.31±0.27[a]
2nd	279.50±65.56[a]	1358.60±93.56[a]	6.55±0.44[a]
3rd	282.28±61.98[a]	1512.52±70.39[b]	7.56±0.22[b]
4th	285.48±78.12[a]	1468.47±65.59[b]	7.36±0.39[b]
5th	255.16±55.04[b]	1368.16±70.80[a]	6.59±0.35[a]
Farming systems			
Only animal husbandry	277.63±49.09	1410.34±75.65	6.85±0.40
Mixed farming	274.22±79.43	1403.44±65.87	6.92±0.36

Values superscripted by similar letter were not significantly different from each other.

Seasons of calving had significant ($P \leq 0.01$) influence on LMY, its contribution to the total variation in the trait being 1.91%. The cows calved during July-Oct (1482.05±68.90 litres) had significantly higher LMY than those calved during Nov-Feb (1376.39±74.50 litres) and Mar-June (1364.23±84.32 litres). Parity effect contributed significantly (P0.01) to the total variation in LMY, the magnitudes of contributions being 4.11% (Table-1). The third (1512.52±70.39 litres) and fourth calvers (1468.47±65.59 litres) had significantly higher LMY than fifth (1368.16±70.80 litres), second (1358.60±93.56 litres) and first (1320.26±49.97 litres) calvers. There was an increasing trend in LMY from first to third parity, then there was a decrease in LMY from fourth to fifth parity. The farming system did not have any significant influence on LMY.

Peak yield: The overall Least squares means for PY in the present study was 6.880.38 litres. Genetic group had significant ($P \leq 0.01$) influence on PY, its contribution to the total variation in the trait being 85.21%. HF crossbred cows had the significantly higher PY (9.87±0.29 litres) than that of indigenous cows (2.54 ±0.41 litres). Variation in zone had also significant ($P \leq 0.05$) influence on PY (Table-1). The urban zone of study area had significantly higher average PY (7.34 ±0.35 litres) than that of peri-urban zone (6.54±0.44 litres). Herd size did not influence PY significantly (Table-1). Seasons of calving and lactation order had significant (P0.01) influence on PY. The cow calved during July-Oct (7.42±0.37litres) had significantly higher PY than those calved during Nov.-Feb. (6.63±0.43 litres) and Mar-June (6.590.31 litres). The third (7.56±0.22 litres) and fourth calvers (7.36±0.39 litres) had significantly higher PY than fifth (6.59±0.35 litres), second (6.55±0.44 litres) and first (6.31±0.27 litres) calvers. The farming system did not have any significant influence on PY.

Discussion

The estimated value for LL was lower than the standard lactation value (305 days) desirable for profitable milk production. Average LL for indigenous cattle was considered to be six months in Ethiopia [2]. Effect of genetic group was also reported to have a significant effect on LL by many authors [15-19]. The mean LL of crossbred cows in this study was smaller than the mean 350 days reported in local crossbred dairy cows in Arsi region in Ethiopia [20]; 333.9 days reported in crossbred cows in North Showa zone, Ethiopia [21] and 11.7 months in Central Highland of Ethiopia [22]. Lower LL values were recorded as 9.13 ±1.99 months reported *in* Zebu X Holstein-Friesian Crossbred Dairy Cows in Jimma Town, Oromia, Ethiopia [23]; 10.1 months in smallholder dairy system in Bahirdar Zuria and Mecha Woredas, Northern Ethiopia [24] and 8.63 months in Yerer watershed Adalibeb woreda, Oromia region, Ethiopia [25]. Feed availability and differences in the management practices in different agro-ecological systems are likely the important contributory factors for the observed variation in LL.

Zone, herd size and seasons of calving had no significant influence on LL. Influence of seasons of calving on LL was also reported to be non significant in Arsi and Zebu breeds of cows and its crosses with Jersey and Holstein-Friesian in Arsi region of Ethiopia [16] and indigenous as well as crossbred cows in India [19]. An increasing trend was observed in LL from first to fourth parity, then a significant decrease in the fifth parity. Influence of parity on LL was in agreement with many works in Ethiopia and tropics [16, 19].

Effect of genetic group was also reported to be significant on LMY by many researchers [15, 16, 19]. The findings indicated that for relatively higher milk production in the agro-socio-eco-system prevalent in and around Gondar, HF crossbred cow is superior over indigenous cow for higher milk production. Higher proportion of crossbred cows over indigenous cows in urban area may be the plausible explanation of higher LMY in urban area. Significantly higher LMY in animals calved during July-Oct might be due to availability of quality green fodder in abundant quantity in study area i.e. first 3-4 months of their post-calving. Influence of season of calving was also reported to be significant in crossbred and indigenous cows in tropics [19]. On the contrary, it was reported to be non significant in Arsi and Zebu breeds of cows and its crosses with Jersey and Holstein-Friesian in Arsi region of Ethiopia [16].

There was an increase in the average LMY from first to third order of lactation and then after it decreased gradually up to fifth lactation. More or less similar trend of variation in LMY due to variable order of lactation was also reported in India [18, 19, 26]. Significant influence of parity on LMY was also reported in Arsi region of Ethiopia [16].

Achieving peak milk yield in the lactation curve has been a topic of discussion for a long time in dairy nutrition, and a benchmark used by dairymen as an indicator of early lactation and transition of cow nutrition. Most cows achieve peak milk yield in about 45 to 90 days in milk and slowly lose production over time until dry-off. Effect of genetic group was also reported to be significant on PY by other authors [19, 27]. The trend recorded in this study was in accordance with the expectation because Friesian crossbred cows are the highest milk producers in the world and the indigenous cows were mostly non-descript having the lowest potency to produce milk among the animals of different genetic-grades. The findings were in corroboration with the finding of other authors [28, 29]. In one study, PY was reported to be from 7.0 kg to 12.7 kg in two breed crosses involving Boran and Horro with various levels of Holstein-Friesian in three locations (Bako, Debre Zeit and Holetta) in Ethiopia [27]. Higher proportion of crossbred cows over indigenous cows in urban area may be the plausible explanation of higher PY in urban area.

No significant influence of herd size on PY was also reported in indigenous and crossbred cows [19]. However, in other study, this effect was found to be significant in the crossbred cows [26]. Such variation may be due to variation in sample size, size of the herds, and genetic constitutions of the experimental animals and/or agro-climatic condition of the experimental area in different studies.

Significantly higher PY was recorded during calving occurred in July-Oct. Availability of fodder due to rain is the most plausible explanation for difference of PY with other season. The trend of variation in PY due to parity was similar to that for LMY as these two traits are supposed to be positively correlated traits. The trend of variation in PY recorded in this study was in agreement with the findings of other authors [18, 19].

Conclusion

The dairy sector of the study area is characterized by a poor genetic potential of indigenous cows. HF crossbred cows have relatively better productive performances. This calls for a planned technical and institutional intervention for improved support services for appropriate breeding programmes, improved cows and adequate veterinary health services. The significant effects of location of herd, season of calving and lactation number (parity) on the performance traits suggested that improvement in feeding and management is the key factor for further improvement in production.

Improvement and expansion of crossbred dairy cattle production at smallholder level in the study areas should be encouraged. Moreover, in line with this, a sustainable extension service to improve animal feed resources management and animal health care also deserve due attention.

Authors' contributions

NK designed the experiments and approved the experimental protocol. AE collected data from the study area. NK and AT drafted the manuscript. NK, HAY and AT did statistical analysis and critically reviewed the manuscript. All authors read and approved the final manuscript.

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Competing interests

The authors declare that they have no competing interests.

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