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Original Article

Evaluation of Reproductive and Productive Performance of Indigenous Dairy Cows

Lakew Alemu [1], Elias Bayu [2], Ayantu Mekonnen [3] and Worku Masho [4]

[1]Bench Sheko Zone Agriculture Development Department, Ethiopia
[2]Mizan Tepi University, college of agriculture and natural resource and department of animal science, Ethiopia
[3]Ayantu Mekonnen, Wellega University, Ethiopia
[4]Mizan Tepi University, College of Agriculture and Natural Resource and Department of Animal Science, Ethiopia

ABSTRACT

Evaluations of the reproductive and productive performances of local dairy cows were carried out in Shaybench and Sheko districts under the smallholder farmers' management system. For the study, a cross-sectional survey and -a semi-structured questionnaire was used to collect data from 180 households. Follow-up studies were also conducted to obtain milk production based on lactation stages. The data were analyzed through a general linear model of SPSS version 20. Cattle are reared primarily for their milk production, drought power, and income source in the study area. The results of the study showed that from the follow-up study, the mean daily milk yield for the first, second, and third stages of lactations were 3.01±0.12, 2. 83±0.26, and 1.75± 0.05 liter per cow respectively. The milk yield decreased significantly in the third stage of lactation than that in the first and second (P<0.001). The milk yield observed was significantly different at (P<0.01) higher in the morning than in the evening for the three stages of lactations. From survey results, the overall mean of AFS, AFC, CI, DO and NSPC were (50.72±0.20 and 44.28±0.0.60 months),

Corresponding Author: Worku Masho < hadhamashoworku@gmail.com>

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(50.50±0.20 and 50.40±0.0.20 months), (21.84±0.14 and 19.56±0.4 months), (16.24±0.30 and 16.20±0.20 months) and (2.30±0.20 and 2.01±0.03 times), in Shaybench and Sheko districts respectively. All of the considered traits for reproductive performances were significantly ($p<0.001$) different between the districts. Thus, it could be concluded that the results reported for reproductive and productive performances in both districts were below the optimum value of 10 months of dairy cows' production. Therefore, Milk production performance and reproductive performance of local dairy cows in the study area were almost similar to the performance of zebu cattle.

Keywords: Local dairy cows, Production Performance, Reproductive performance, Bench Sheko.

INTRODUCTION

Livestock in Ethiopia has been contributing an impressive portion to the economy of the population and still promising to meet the economic improvement of the nation (Metaferia *et al.,* 2011). The estimated cattle population in Ethiopia is 60.39 million head. Out of the full cattle populace, female cattle constitute almost 54.68% and the remaining 45.32% are male cattle (EATA, 2013). Dairy cattle are assessed to be roughly 12.3 million and milking cows are around 6.6 million heads. According to the CSA (2017/18), the assessed total milk in the country is almost 3.13 billion liters. The average milk yield per cow per day is about 1.37 liters (CSA, 2017). The per capita milk consumption was only about 19/kg/year which is much inferior to African and the world's per capita averages of 40 kg/year and 105 kg/year respectively (Winrock International, 1992; Shiferaw, 2014). This low per capita milk consumption mainly comes from the poor genetic potential of indigenous cattle for dairy traits (MOA, 2012). The average lactation milk production of the indigenous cow's ranges from 494-850 kg under optimum administration (Haile et al., 2009; Shiferaw, 2014).

The indigenous dairy cattle breeds of the tropics are ascribed to natural choice to the tropical environment. They are well known for their flexibility to adapt, toughness, disease resistance, and heat tolerance; survive under low quality and quantity feed and low supervision levels (Alberro and Hailemariam, 1982; Alemshet, 2014). To meet the ever-increasing demand for milk and milk products, hereditary enhancement of the indigenous cattle has been proposed as one of the opportunities. Genetic improvement of the indigenous cattle focusing on cross-breeding has been practiced in many developing countries including Ethiopia (CSA, 2017/18; Shiferaw, 2014).

Dairy cattle breeding is therefore changing direction and moving towards more viable milk production, with a focus on enhanced productivity and functionality (Bebe *et al.*, 2000; Destalem, 2015). In addition, a new approach known as the genomic selection has been implemented in numerous breeding patterns worldwide. In genomic selection, genomic enhanced breeding values (GEBV) are assessed for selected candidates as the sum of the effects of high-density markers (Pryce & Hayes, 2012). The advancement of genomic selection has commanded a high level of expectation about increased genetic gain in dairy cattle breeding programs (Dekkers, 2010). Breeding programs with progeny testing and

intensive use of artificial insemination (AI) have for many decades been the foremost apparatuses in making a high-yielding dairy cow. Breeding values for AI bulls can be assessed very accurately with phenotypic information on large progeny groups and relatives. However, information is limited about the productive performance of dairy cows in the smallholder urban and peri-urban dairy farms in the tropics, predominantly in Ethiopia (Lobago *et al*., 2007, Niraj *et al.*, 2014). Since the large volume of milk in the country is achieved mainly (98.20%) from the indigenous breed (CSA, 2017/18), the performance record of local cows is essential for scheming breeding as well as management strategies to develop the dairy sector. So, there is a condition of evaluation of the reproductive and productive performances of local dairy cows under the current study area.

MATERIALS AND METHODS

Description of the Study Area

The study was conducted in selected districts of the Bench Sheko Zone. Bench Sheko zone is found at 34°45'to 36°10' East and 5°40'to 7°40' North. Agro-ecologically, Bench Sheko Zone consists of 52% lowland (< 1500 meters above sea level), 43% midland (1500-2300 masl), and 5% highland (> 2300 masl). The altitude ranges from 850 to 3,000 masl. The annual average temperature ranges from 20 to 40°C, while the annual rainfall ranges from 1200 to 2,000 mm (BMZFED, 2015). It is bordered by Kaffa Zone in the North, with West Omo Zone in North East, with Shaka Zone in South West, and with Gambela in the south (BMZFED, 2018). The majority of the population depends on crop production, animal production, and beekeeping. The main livestock species reared in the zone are cattle, sheep, goats, poultry, and equines.

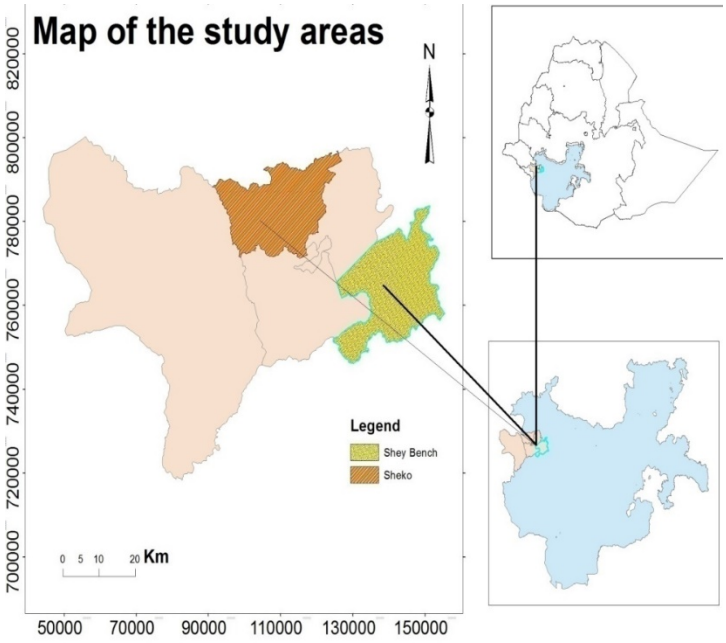

Figure 1: Map of the Study Area

Sampling technique and sample size determination

For the study, a cross-sectional survey and semi-structured questionnaire, as well as focus group discussions, were used to collect data from identified households. Two districts from the Bench Sheko zone, Shey Bench and Sheko were selected based on their potential for dairy production in the study area. From each district, three kebeles were selected by using purposive sampling techniques depending on the cattle population and motor ability to the road. In the same manner, 30 households were selected randomly from each selected kebeles making a total of 180 households. The formal survey was conducted by enumerators under close supervision and participation of the researchers. A focus group discussion with eight to ten farmers (8-10), who had previously participated in the household survey, was carried out in each of the six villages. Hence, a total local cow beneficiary sample size (household) included in the study was determined according to the formula given by (Cochran, 1963).

Total sample (N) = $Z\alpha^2$ x p (1-p) / d2

Where:

N = required sample size

P (expected proportion) = 0.135 (if the population is homogeneous), d (desired absolute precision) = 0.05, Zα = 1.96 (is the abscissa of a normal curve that cuts of an area at the tails (1-α equals to the desired confidence level, for 95%=1.96). For the survey, a required sample size of the respondent with a 95% confidence level was calculated as,

N=Zα2×p(1-p)/d2=[(1.96)2×0.135(1-0.135)]/(0.05×0.05=3.8416×0.1168/0.0025=180 respondents.

Animal management and Monitoring

The cows are managed by free grazing throughout the day. The feed on which the animals are fed includes natural pasture, hay, crop residue, and rarely non-conventional feeds. Cows were hand-milked twice per day, early in the morning and evening. A follow-up study was conducted to evaluate the milk yield of cows based on lactation stages, parity, and lactation month. In this section, a diagnostic survey was undertaken to identify 90 households (45 from each district) that have lactating cows in all districts. Lactating cows were stratified into early (1–2 months), mid (3–4 months), and late (5–6 months) lactation stages depending on their lactation length to see the production potential at different stages. Each lactation stage was comprised of 40, 30, and 20 milking cows respectively. To see the effects of parity, lactations were classified into three parities 1, 2, and 3+. Parity three and above were all pooled together as parity three due to very few number observations in later lactations as well as due to the higher correlation between 3rd and later lactations. In addition, lactation month during the monitoring period (November, December, and January) was considered. Finally, daily cow milk yield (morning and evening) was measured using a calibrated plastic jog for three months.

Data Analysis

Statistical Analysis

The data were analyzed with SPSS version 20 software (SPSS, 2015). This involved simple descriptive statistics. GLM (General Linear Model) procedure was used to test the effects of lactation phase, parity, agro-ecology, and lactation month on morning milk yield (MMY) and evening milk yield (EMY). Similarly, daily milk yield, lactation milk yield, lactation length, age at first service, age at first calving, calving interval, and days open were compared under different agro-ecologies. The presence of any significant differences was checked by using Tukey Kramer multiple comparison tests at $\alpha < 0.05$. The following formula was used to compute the index as a variable with the highest index value being the highest economically important (Kosgey, I .S. 2004).

Model Equation for Monitoring Study

The model equation for morning and evening milk yield

The model equation for morning and evening milk yield is as below:

Yijklm = μ+ Ai+Pj +Lk+Sl +eijklm

Yij = the ith observation of morning and evening milk yield

μ= the overall mean

Ai= the effect of agro-ecology

pj= the effect of parity

Lk = the effect of lactation phase

Sm= the effect of lactation month

eijkm = random error, which is assumed to be normally and independently distributed with a mean of zero and constant variance.

Model used for reproductive traits

Yijkl = μ + Ai + Sj + Pk + eijkl, where, Y*ijkl* is the observation on CI and DO, μ is the overall mean, A*i* is the fixed effect of *i*th agro-ecology, *Sj* is the fixed effect of *j*th season of calving of the cow, P*k* is the fixed effect of *k*th dam parity, e*ijkl* is the effect of random error.

RESULTS AND DISCUSSION

Purpose of keeping cattle in the study area

The major functions of indigenous cattle reared in the Bench sheko zone are summarized in Table1. The farmers in both the districts reared cattle primary for milk production, draught power, and source of income, ranked 1st, 2^{nd,} and 3rd respectively. In Bench Sheko Zone, local farmers had a clear hierarchy for their production objectives, with high importance on livestock functions linked to crop production, milk production, draft power, and savings. A strong desire for milk production might be related to the culture of the Bench and Sheko people who are known for the

consumption of traditional foods made from milk and milk products. According to the finding of Endashaw (2010) Mursi cattle in both Mursi and Bodi community rear their cattle primarily for milk. Kerry cattle in the northern part of Ethiopia are reared primarily for their milk production and source of income. Additionally, the importance of draught power, saving and manure functions underline the strong integration of crop and cattle production in the study area. Similar to the current study, Tekleyohannes *et al*., (2012) noted that in the crop-cattle livestock production environment, farmers preferred hardy and docile animals. The current finding was also comparable with the findings of similar studies conducted in Kenya and Southern Mali (Mwacharo and Drucker, 2005; Traoré *et al*., 2016). In developing countries, especially in low-input smallholder production systems, the most valuable livestock attributes are often those that successfully guarantee multi-functionality, flexibility, and resilience to deal with variable environmental conditions (Sheferaw, 2014).

Table 1: Rankings of the purpose of keeping cattle as indicated by respondents

Purpose of keeping cattle	Districts							
	Sheybench				Sheko			
	Rank			Index	Rank			Index
	1st	2nd	3rd		1st	2nd	3rd	
Milk	90.8	2.5	0.8	0.46	74.2	19.2	5	0.44
Draught power	7.6	82.5	11.7	0.33	14.1	57.5	21.7	0.29
Income	0.8	10.5	55.8	0.13	6.7	11.7	37.5	0.13
Manure	0.8	4.5	19.2	0.05	2.5	10.8	25	0.09
Trashing crop	0	0	7.5	0.01	0.8	0	8.3	0.01
Social value	0	0	4.2	0.007	0	0.8	1.7	0.01
Meat	0	0	0.8	0.001	1.7	0	0.8	0.09

N=number of observation (households); Index = Σ of [3×ranked 1st + 2×ranked 2nd + 1× ranked 3rd] given for particular valued traits divided by Σ of [3×ranked 1st + 2×ranked 2nd + 1× ranked 3rd] summed for all valued traits

Production Performances

Daily milk yield from a monitoring study

Morning and evening milk yields monitored by enumerator local dairy cows were shown in Table 2. In all aspects, the milk yield was observed meaningfully higher in the morning than in the evening for the three phases of lactations. The results of the current finding discovered that lactation milk yield appears like linearly increase from 1st to 3rd parity. This increasing inclination might be due to the increase in body weight combined with advancing age at full development of secretory tissues of the udder (Shiferaw, 2003). Morning and evening milk yields of monitored indigenous dairy cows were significantly influenced by the respective lactation months (Mebrahtom and Hailemichael, 2016). The average morning and evening milk yields

gradually increased from November to January. The significant effect of lactation months could be related to the availability of feed resources, since in January it is well known that cows reduce production with either acute or chronic exposure to feed shortage, whilst in November and December the availability of green forages is better compared to January due to availability of more rain in the study areas. Similar to the current study significant effect of lactation month was reported on morning and evening milk yield of Holstein Friesians cows in Ethiopia (Destaw *et al*., 2016).

The overall least-square means of morning and evening milk yield of local dairy cows in the monitoring study were 1.75 ± 0.17 and 0.77 ± 0.04 respectively. The mean value found in this study was higher than the morning and evening milk yield reported in Guraghe Zone (Wondoson *et al*., 2017.) which was 0.99 ± 0.02 and 0.73 ± 0.02 respectively.

Table2: Mean monitored milk yield (litters/day) of local cows in the study area

Factors	Milking time				Over all mean		P-value
	MMY		EMY				
	N	LMS±SE	N	LSM±SE	MMY	EMY	
Lactation phase					1.75±0.17	0.77±0.04	0.000
- phase 1	40	2.16±0.02	40	0.85±0.03			
-phase 2	30	1.86±0.46	30	0.97±0.06			
-phase 3	20	1.25±0.05	20	0.50±0.04			
Parity					1.50±0.01	0.83±0.03	0.000
1	20	0.90±0.01	20	0.75±0.03			
2	30	1.53±0.01	30	1.09±0.04			
3	40	2.09±0.02	40	0.64±0.03			
Districts					1.11±0.04	0.82±0.03	0.000
Sheybench	45	1.30±0.05	45	0.90±0.03			
Sheko	45	2.03±0.03	45	0.73±0.04			
Lactation Month					1.72±0.03	0.81±0.3	0.000
November	30	2.13±0.02	30	0.83±0.03			
December	30	1.70±0.04	30	1.05±0.04			
January	30	1.33±0.05	30	0.55±0.03			

MMY= Morning milk yield, EMY= Evening milk yield.

Estimated Milk Production Compared with Stage of Lactation

The milk production performance at different stages of lactation and lactation of dairy cows across the production system was revealed in Table 2. The milk production significantly (P<0.01) decreased in the late stage of lactation than in the mid and early

stages of lactation (2.16±0.02, 1.86±0.46, and 1.25±0.05). According to Asaminew and Eyassu (2009), the average daily milk yield of local cows was 2.0, 1.2, and 0.6liters for the first, second, and third lactations, respectively, with an overall average of 1.2 liters per day in Bahir Dar Zuria and Mecha woreda of West Gojam Zone in Amhara Regional State. From the monitoring study; the mean morning milk yield of local cows in the study area was 1.11±0.04 liters, which is similar to the national average which was 1.09 liter but the evening milk yield was lower (0.82±0.03). According to the report of Degena and Adugna, (1999), and Kedija, (2007) in Mieso district reported that the overall cow milk yield/head/day for the monitored cows was 1.24 ± 0.02 liters.

Milk production performance compared with parity as presented in Table 2, the effect of the parity number was highly significant ($P<0.01$) for daily milk yield. Milk production increased as parity number increased until 3rd then decrease with the advance of Parity. This result agreed with the finding of Mohamed (2004) who demonstrated that milk yield increased with advancing lactation parity in Sudan.

Reproductive Performance of local dairy cows in the study area

Age at first service

As summarized in Table 3, there is a significant difference ($p<0.05$) in the age of the female and males at first service (AFS) by the respondents in the current study. The current result of AFS was higher than the result of Adebabay (2009) in Bure district, for Simada cattle in Tach Gayint district (Assefa *et al*., 2015), Zewidie (2010) reported for indigenous dairy cows in Ziway area and reports of Wondoson *et al*., (2017) for Guraghe highland cows. Age at first service (AFS) is the age at which heifers get body condition and sexual maturity for accepting service for the first time (Gidey, 2001; Alemshet, 2014). AFS signals the beginning of the heifer's reproduction and production and influences both the productive and reproductive life of the female through its effect on her lifetime calf crop (Alemshet, 2014). According to Mukassa-Mugerewa (1989), the longer age at first service in the study area might reflect late age at maturity. Nutrition and overall management of the cow can impact the circulating concentrations of hormones and metabolites, and these alterations can have positive and negative impacts on reproductive performance (Gebeyehu *et al.,* 2005; Belay *et al*., 2012). Therefore, improved management levels such as good nutrition, housing, and health care enhance the growth rate of heifers to come on first heat at an early age.

Age at first calving

Age at first calving is an economically important trait that can help to estimate the productive and reproductive performance of a given animal in its future life (Alemshet, 2014). AFC of the current study was shown in Table 3. The heifer delivers

its first calf approximately at the age of 4 years. Moreover, AFC was significantly different across locations with significantly shorter AFC in Sheko than Sheybench which might be due to higher temperature which might initiate quickly age at first heat in Sheko relative to Sheybench. The overall mean AFC of local cows in the study area was lower than 51.9±5.9 months reported by Debir (2016) in Sidama Zone, 51.24±0.55 months reported by Beriso et al., (2015) in Chuko district, Southern Ethiopia, Kebede et al., (2017), Dessalegn (2015), Endashaw and Tadelle (2015) who reported that 4.7 ± 1.31, 4.98 ± 0.68 and 4.6 years for Gofa cattle, cattle in former Benchi-Maji Zone and Mursi cattle respectively and higher than the mean of AFC of Begait cattle (48.8 months) Mulugeta (2015) and Chacha area cattle, North Show zone (47.16± 8.7months) (Mulugeta and Belayneah, 2013) and local cows under farmer's management in and around Mekelle, Ethiopia(Kumar et al., 2014). Such variations might be due to differences in locations, availability of feed resources, and other husbandry practices.

Calving interval

The overall estimated mean calving interval (CI) in the current study was 20.70±0.27 months and differs significantly among agroecology of the study area ($P<0.05$) (Table 3). The result of the current finding was longer than the CI of 19.93±0.2 months estimated by Beriso et al. (2015) for local breed cows, in Aleta Chuko district, 15.7 months reported by Zewidie (2010) for indigenous dairy cows in the Ziway area, and 13.3 months reported by Alemselam et al. (2015) in and around Mekele. Calving intervals for the current study were shorter than 21.18 months reported by Dessalegn (2015) in the former Bench-Maji Zone, South West Ethiopia, 26.04±0.01 months reported by Assefa *et al.* (2015) for Simada cattle in Tach Gayint district as indicated in Table 3. The opening time between two consecutive calves is called the calving interval (Mulugeta and Belayeneh, 2013; Habtamu *et al.,* 2018). The differences in calving interval could be due to the longer time taken by dairy cows to conceive due to the effect of nutrition and other management aspects like health care within consecutive calving among agroecology (Habtamu *et al*., 2018).

Days open

As indicated in Table 3, the overall estimated mean of days opens till conception was 16.22±0.25 months. This finding was higher than the reports of Yifat *et al*., (2012) reported 11.3 months and Wondoson *et al.,* (2017) in the Guraghe zone reported 12.70±0.37 months. The current result was higher than local cows in and around Mekele (Kumar and Tkui, 2014) and local cows in and around Gonder City Ethiopia (Kumar *et al*., 2014). The present result indicates prolonged days open beyond the ideal 90 days intervals. Feed shortage, silent estrus, lack of proper heat detection, and nutritional deficiencies coupled with heavy internal and external parasite load on the

cows might have other contributory factors for a long DO report in this study (Gebrail *et al*., 1983).

Number of services per conception (NSPC)

NSPC shows how many services are required for a successful conception of breeding animals and it is calculated by dividing the number of conceptions by the number of inseminations (Habib *et al.,* 2010; Kumar *et al*., 2014). According to Table 3, the average number of services per conception of dairy cows for Sheybench and Sheko were reported by the respondents as 2.30 ± 0.20 and 2.01±0.30, respectively. There was a significant difference in NSPC between the two districts ($p<0.01$). The overall estimated mean for the number of services per conception (2.16±0.16) in this study was lower than the result of 2.2±0.2 for indigenous cows in and around Mekele (Kumar *et al*., 2014) and higher than 2.0±0.65 reported in smallholder farm conditions in and around Maksegnit town (Tadelle and Nibret, 2014) **and** 2.2±0.2 in local cows of Gondar city, Ethiopia (Kumar *et al.,* 2014). Gebrekidan *et al.,* (2014) illustrated that number of services per conception is influenced by the availability of feed and high environmental temperature. Lack of knowledge, inappropriate time of insemination, unqualified technicians, hygienic problems, and disease are the most common reasons for frequent breeding (Regassa *et al*., 2016).

Table 3: Household response of reproductive performance of dairy cows

Characters	Districts			P-value
	Sheybench N=90 LSM±SE	Sheko N=90 LSM±SE	Overall N=180 LSM±SE	
Age at puberty in male (month)	49.32±0.7	45.96±0.7	47.64±0.7	**
Age at puberty in female (month)	50.72±0.6	44.28±0.6	47.50±0.6	**
Age at first calving (month)	50.50±0.20	50.30±0.20	50.40±0.2	**
The reproductive lifespan of cow (year)	13.28±0.3	14.05±0.3	13.67±0.3	NS
The reproductive lifespan of bull (year)	3.84±0.30	3.64±0.12	3.74±0.24	NS
Lifespan calf crop production (no.)	5.63±0.14	7.29±0.14	6.46±0.14	**
Calving interval (month)	21.84±0.14	19.56±0.4	20.70±0.27	**
Days open (month)	16.24±0.30	16.20±0.20	16.22±0.25	**
Several service per conception (no.)	2.30±0.20	2.01±0.03	2.16±0.16	**

N=Sample respondents; Ns =Non-significant (P > 0.05); **P <.01, LSM= least square mean; SE=standard error, NSPC= Number of service per conception

CONCLUSIONS

This study aimed to evaluate the productive and reproductive performances of the local dairy cows, to identify major constraints, cattle breeding activities, and farmers' trait preferences on indigenous dairy cows in Sheybench and Sheko districts within Bench Sheko Zone under the smallholder farmer's management system. For the study,

a cross-sectional survey and structured questionnaire, as well as focus group discussions, were used to collect data from 180 households. A follow-up study was also conducted to obtain morning and evening milk production based on lactation stages. The data were analyzed by the general linear model procedure of SPSS version 20. The milk yield decreased significantly in the third stage of lactation than that of the first and second significantly different at ($P<0.001$). The milk yield was observed significantly ($P<0.01$) higher in the morning than in the evening for the three-stage of lactations. Reproductive performance traits are significantly (different at $P<0.01$) except reproductive life span of cows and bulls. Therefore, Milk production performance and reproductive performance of local dairy cows in the study area were almost similar to the performance of zebu cattle

RECOMMENDATIONS

Designing and implementing of community-based dairy cows breeding program should focus on genetically improve growth rate and conformation to improve milk yield in the study area is suggested.

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CONFLICT OF INTEREST

The authors state that they have no financial, economic, or intellectual conflicts of interest concerning the topic of this paper.

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