RESEARCH ARTICLE

Impact of feed optimization and extension intervention on productive and reproductive performance in commercial dairy farms of urban areas in the eastern region of Ethiopia

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Abstract: This study aimed at assessing the husbandry practices and evaluating the impact of feed optimization on productive performances and reproductive disorders of dairy cows. The study was conducted on purposefully selected 76 and 16 dairy farms for pre-and post-intervention study, respectively, from Harar and Dire Dawa cities. Data were collected by semi-structured questionnaires and focused group discussion starting from October 2018 to September 2020. Commonly used feeds were standardized to the cows' requirement. Milk yield was recorded every day for four consecutive months while milk composition was evaluated every month. Data analysis was done by SPSS, one-way ANOVA, and t-Test. The pre-intervention results showed that farmers from the small, medium, and large-scale farms fed cows on low concentrate quantity of 3.76, 4.61, and 5.84Kg/day, respectively. The quantity of concentrate supplementation per cow per day was significantly different ($p < 0.0001$) among farm-scales. Cows maintained under different farm-scales produced low milk yields (9.57-13.07 litter). Cows from large-scale farms significantly produced milk with lower fat ($P < 0.0006$) whereas small-scale farms produced milk with lower protein and milk urea ($P < 0.0001$). All milking cows maintained in small, medium, and large farm-scales were highly affected by anestrus (44.45%), placenta retention (35.19%), and repeat breeding (20.37%). The technical intervention of feed optimization boosted daily milk yield from 17.64 to 27.44%, enhanced most milk components except fat and milk urea, and reduced the

incidence of anestrus (11.11%), retention of the placenta (5.56-11.11%), repeat breeding (11.11-22.22), dystocia (5.56-11.11%) and prolapse (5.56%). Finally, this study concluded that regular technical advice and feed optimization improved milk production and reduced reproductive disorders of dairy farmers in all farm categories.

Keywords: Cows, Farm-scales, Intervention, Milk production, Reproductive disorders

Introduction

In Ethiopia, market-oriented dairy farming primarily contributes to the supply of milk and milk products in urban centers (Mekonnen et al. 2006). The Ethiopian government has recently given considerable attention to the need to increase milk production (Belay and Geert, 2016). For this purpose, the government consistently introduced improved breeds and semen to dairy farmers. These genetically improved breeds are mostly kept in the urban area of the country due to the adequate availability of feeds and veterinary services (Azage et al. 2013). The urban commercial dairy producers would rely almost exclusively on artificial insemination for better semen and pay for the more expensive imported genetics and breeding supplies. Despite this, cows reared under different commercial farm-scales were producing less daily milk, 5–15 litres (Azage et al. 2000), and total milk production per lactation, 3208.56 litres (Dessalegn et al. 2016) which is by far lower than 5807 litres reported in other African countries (Naceur et al. 2012). The lower milk production under commercial farms can be attributed to many constraints, but the most important factors repeatedly raised are the animal's genetic potential and feed (Belay and Geert, 2016). However, so many dairy farmers claim that poor breed quality has much more adverse effect on milk production than inadequate feeding. Conversely, others (Van Marle-Köster and Webb, 2014) suggested that the improvement of the genetic potential of dairy cattle increases milk yield if feed management skills are acquired and animal health care services are accessed by dairy farmers. For this reason, this research was done to examine the effect of feed optimization along with training, advice, and proper follow-up action on milk production and composition and reproductive disorders of dairy farms with different husbandry practices and

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farm-scales. Therefore, the objectives of this study were to assess the husbandry practices and standardize feed to the requirements of peak stage lactating cows and evaluate its impact on milk yield, milk composition, and reproductive disorders of lactating cows maintained under different husbandry and farm sizes.

Materials and Methods

Baseline and post-intervention study

The study was conducted in the eastern region of Ethiopia in and around Dire Dawa and Harar cities. Based on their willingness to engage in training and share experience at Haramaya University dairy farm, 23 small-scales (owned milking cows ≤ 10 ; 10 from Dire Dawa and 13 from Harar), 34 medium-scales (owned milking cows between 11 to 20; 18 from Dire Dawa and 16 from Harar), and 19 large-scales (owned milking cows >20 ; 12 from Dire Dawa and 7 from Harar) were purposefully selected. Survey data on husbandry practices were collected using semi-structured questionnaires, detailed assessment of farm notebook records, and focused group discussion (FGD). A total of 152 Holstein Friesian with Zebu crossbred cows (HFCC) within 3-5 parity, two from each farm were deliberately selected based on their population and assessed for their reproductive disorders, milk yield, and composition. A format was distributed to each farm to record data on milk and reproductive disorders by the farm head and was collected monthly. Reproductive disorders such as retained placenta, dystocia, anoestrus, repeat breeder, and prolapse that occurred to each cow in each farm were recorded based on existing definition (Adane et al. 2017). All identified dairy farm owners and/or their representatives were invited and trained on dairy production and management and shared practical skills at the Haramaya University dairy farm. Then, each farm was visited once monthly for four consecutive months during the pre-intervention to crosscheck the actual and adapted practices regardless of their farm-scales. However, only 16 farm owners (8 medium-scale; 4 from Dire Dawa and 4 from Harar, and 8 large-scales; 4 from Dire Dawa and 4 from Harar) who fulfilled all the required quantity and necessary feed ingredients used in ration formulation were purposefully considered in the post-intervention assessment. The post-intervention assessment was done on 48 HFCC (3 milking cows from each farm) which were purposefully selected based on their similar pregnant stage and parity then monitored starting from three weeks before calving to 120 days post-calving. The advice was given to all farm attendants to feed their cows separately twice a day at a rate of 0.5 kg per 1 kg of milk (Pandey and Voskuil, 2011), provide water and roughage feeding *ad libitum*, and to measure daily feed and milk produced.

Nutritional analysis and ration formulation

Milk sample was taken every month from each cow (100 ml) and pooled for cows in the same farm and separately analysed in

duplicate for composition in the morning and afternoon by Milko-Scan™ FT1. Commonly provided feed was collected from each farm and samples of the same feed type were pooled, thoroughly mixed, sub-sampled (500 g) and analysed (AOAC, 2000) for their nutritional content. Accordingly, a ration was formulated from ground maize, wheat bran, wheat short, soybean meal, peanut meal, salt, ruminant premix, and di-calcium phosphate by feedWin at a proportion of 29, 31.2, 18, 5, 15, 0.8, 0.5, and 0.5%, respectively, so that it contains 18.02 crude protein and 61.2% TDN. Thereafter, the format that indicated this feed proportion was printed and distributed to all farms considered in the post-intervention so that they could make their ration at their farm with the same ingredients and amounts.

Statistical analysis and model

All the survey data were analysed for percentage and means by SPSS version 20. The concentrate supplementation, milk yield, and composition data were subjected to one-way ANOVA of SAS version 9.4 while the comparison data were analysed by t-Test Paired for two samples for means to recognize the impact of the technical-intervention. The statistical model: $Y_{ij} = \mu + F_i + e_{ij}$; where: Y_{ij} is the J^{th} observation of the i^{th} farm-scale; μ is the population mean; F_i is farm-scale (small, medium, and large); and e_{ij} is the random residual effect. The existence of significant effect among farms was separated by Duncan's multiple range tests at 5 % level of significance.

Results and Discussion

Pre-intervention husbandry practices

Across all the farm categories in the study area, Friesian crosses accounted for 82.8 percent and were the largest proportion of the herd maintained by farm owners due to higher milk productivity, but the majority of the farm owners did not know their exact crossbreed levels. Small size dairy farmers keep relatively many local cow breeds in their herd (18.7%) due to the lower feed requirements and a higher concentration of milk solids. Besides, small-scale dairy farming is their ancillary occupation (88.7%) unlike the medium-scale (91.6%) and large-scale (100%) which are running their farm as the main business.

Natural mating was the most (67.5%) practised breeding method in all the study farms whereas AI services were utilized mostly (31.4%) by small-scale farms with a desire to improve the genetic potential of their animals by superior bull's semen. The majority (95.60) of dairy farmers did not keep proper records relating to the date of birth, breeding, vaccinations, past health problems, treatment given, and daily milk yield for individual cows. Almost all farms (95.2%) were managed by owners who did not possess the relevant professional training and this was the cause for a large number of farms being managed in traditional ways with little or no improved management practices. This is in line with

the result indicated by Ponnusamy et al. (2019) and Patel et al. (2020).

Concentrate feeding practices and levels

A majority of dairy farmers fed their milking cows on concentrate at different proportions across all the farm categories (Table 1). The quantity of concentrate supplementation per cow per day was significantly different ($p < 0.0001$) among farm-scales, whereas the quantity of concentrate supplementation per liter of milk was not. The amounts of concentrate used in large-scale farms were higher than in other farm sizes. This indicates that they give more care to their cows as they have comparative advantages in milk production which is consistent with the study reported by Gelila (2017). However, quantities used in all farm sizes were lower than the recommended, 6.5-10.5 kg/day (Kavanagh, 2015). The compound concentrate feeding based on milk yield was also below the recommended, 0.5 kg/kg of milk, which is the point of biological and economic optima (Pandey and Voskuil, 2011).

Milk yield and composition

Mean daily milk yield at peak lactation stage under different farm-scales was significantly different ($p < 0.0001$) (Table 1). The overall recorded daily milk yield per cow in all the farms in the study was lower than the expected level (20 liters) reported in an earlier

study for crossbred cows in Ethiopia (Azage et al. 2000). Cows from the small-scale farms were produced lower yields than cows from the medium and large farm-scales and this is consistent with earlier study reports (Gelila, 2017). This could be due to lower concentrate level utilization. Cows from the large-scale farms were significantly produced milk with lower in milk fat ($P < 0.0006$) than cows from the other farm-scales, whereas cows from the small-scale farms were produced milk with lower protein and milk urea (MU) ($P < 0.0001$) than cows from the other farm scales (Table 1). The fat and solid not fat components from cows of all farms were higher than the lower limit 3.5% and 8.5%, respectively.

Major reproductive problems

Anestrus, retention of placenta, and dystocia were prevalent among the reproductive disorders (Table 2) and this corresponded to results reported earlier (Khan et al. 2016; Patel et al, 2020). Cows maintained under small-scale farms were more affected by anestrus, retention of the placenta, and repeat breeding. This might be due to the lower quantity of concentrate supplementation (Table 1) and the intensive use of AI. The overall prevalence of repeat breeding and anestrus in this study was within the range of 5-30% (Patel et al, 2020; Gupta and Deopurkar, 2005; Hunduma, 2013) and 10-40% reported by Zdunczyk et al. (2002), respectively. The incidence of placenta retention in this study was higher than 18.3% which was reported by Degefa et

Table 1 Pre-intervention concentrate supplementation and milk yield and composition (n=76)

Parameters	Farm scales			P-value	SL
	Small (n=23)	Medium (n= 34)	Large (n= 19)		
Amount of concentrate offered (Kg/cow/day)	3.76 ^c	4.61 ^b	5.84 ^a	<0.0001	***
Concentrate supplement per liter of milk (Kg/litter)	0.39	0.41	0.45	0.4566	NS
Milk yield (Liter/cow/day)	9.57 ^c	11.29 ^b	13.07 ^a	<0.0001	***
Milk composition					
Fat (%)	4.40 ^a	4.00 ^{ab}	3.60 ^b	<0.0006	***
Protein (%)	3.00 ^b	3.81 ^a	3.97 ^a	<0.0001	***
Lactose (%)	4.72	4.70	4.66	0.507	NS
Solid not fat (%)	8.50	8.56	8.54	0.960	NS
Total solid (%)	12.86	12.00	11.91	0.067	NS
Milk Urea (mg/dl)	15.30 ^b	30.01 ^a	30.10 ^a	<0.0001	***

a, b, c- Different superscripts in a row are significantly different at $P < 0.05$. NS=Non-significant; SL=Significant level

Table 2 Major reproductive disorders assessed during pre-intervention study (n=76)

Reproductive disorders	Farm Scales (%)			Overall mean (n= 76)
	Small (n= 23)	Medium (n= 34)	Large (n= 19)	
Anestrus	88.89	27.78	16.67	44.45
Retention of placenta	77.78	16.67	11.11	35.19
Repeat breeding	27.78	11.11	22.22	20.37
Dystocia	0.0	5.56	11.11	5.56
Prolapse	0.0	0.0	5.56	1.85

n= number of sample farms

Table 3 Least mean squares comparison of milk yield and composition for pre- and post-intervention study

Parameters	Farm Scale	Pre-In(n=76)	Post-In(n=16)	P-value	SL	^Δ Change (%)
Milk yield (L)	Medium	11.29 ^b	15.56 ^a	<0.0001	***	4.27 (27.44%)
	Large	13.07 ^b	15.87 ^a	0.0007	***	2.80 (17.64%)
Milk composition (%)						
Fat	Medium	4.00 ^a	3.64 ^b	0.004	**	-0.36 (9.89%)
	Large	3.60 ^a	3.58 ^a	0.920	NS	-0.02 (0.56%)
Protein	Medium	3.81 ^a	3.93 ^a	0.060	NS	0.12 (3.05%)
	Large	3.97 ^a	3.98 ^a	0.920	NS	0.01 (0.25%)
Lactose	Medium	4.70 ^a	4.73 ^a	0.447	NS	0.03 (0.63%)
	Large	4.66 ^a	4.69 ^a	0.502	NS	0.03 (0.64%)
Solid not fat (%)	Medium	8.56 ^b	9.30 ^a	0.024	*	0.73 (7.85%)
	Large	8.54 ^b	10.10 ^a	<0.0001	***	1.56 (15.45%)
Total solid (%)	Medium	12.00 ^b	13.40 ^a	0.007	*	1.4 (10.45%)
	Large	11.91 ^b	12.90 ^a	0.002	*	0.9 (6.98%)
Milk Urea (mg/dl)	Medium	30.01 ^a	20.70 ^b	<0.0001	***	-9.31 (44.96%)
	Large	30.10 ^a	22.20 ^b	<0.0001	***	-7.90 (35.59%)

n=number of sample farms, Pre-In=Pre-intervention, Post-In=Post-intervention, SL=Significance level, NS=Non-significant (p>0.05),

^Δ=Performance change

Table 4 Influence of technical-intervention on some reproductive disorders

Variables	Farm Scale	Pre-In(n=76)	Post-In(n=16)	^Δ changes (%)
Anestrus	Medium	27.78	16.67	11.11
	Large	16.67	5.56	11.11
Retention of placenta	Medium	16.67	11.11	5.56
	Large	11.11	0.00	11.11
Repeat breeding	Medium	11.11	0.00	-11.11
	Large	22.22	0.00	-22.22
Dystocia	Medium	5.56	0.00	-5.56
	Large	11.11	0.00	-11.11
Prolapse	Medium	0.00	0.00	0.00
	Large	5.56	0.00	-5.56

n= number of sample farms, ^Δ= Performance change, Pre-In=pre intervention, post-In=post-intervention

al. (2011). The higher incidence of dystocia noted in the large-sized farms might be due to the heavy grain feeding practices which are in line with the study reported by Grimard et al. (2006). These variations in the prevalence of reproductive health problems might be due to the differences in the husbandry system and genetic blood level of cows in each farm.

Post-intervention husbandry practices

The intervention practice through feed optimization significantly (P<0.0001) increased daily milk yield as compared to pre-intervention assessment (Table 3). This response indicates the higher potential of cows if they feed on the required quantity of balanced ration. In agreement with this study, an increased milk yield by 11.3% was reported after the feed was supplemented with 0.8 kg of concentrate per liter of milk produced (Fike et al. 2003). Besides, many scholars have illustrated an improved daily milk yield from 7 to over 24 liters (Lanyasunya et al. 2001) and 6.7-

7.6% (Garg et al. 2014) after cows were fed a balanced ration. The technical feed intervention significantly (P<0.05) improved milk protein by 3.05 and 0.25%, respectively, in medium and large-sized farms, while it decreased fat by 9.89 and 0.56%, in that order (Table 3). The decreased milk fat content in response to supplemented ration is consistent with the study finding reported by Garg et al. (2014). The decreased fat content can be attributed due to an increase in milk quantity in response to the higher concentrate supplementation which is in line with Ponnusmy et al. (2019).

An increased milk yield and milk components in this study could be due to an increased rumen microbial nitrogen synthesis in response to the feed optimization. Besides, the decreased MUN implied that cows were fed on a balanced ration with a suitable protein to energy ratio. The technical feed intervention also significantly (P<0.05) decreased the incidence of reproductive disorders as compared to pre-intervention (Table 4). The

reduction of anestrus incidence is consistent with Alam and Sarder (2010). The more incidence of anestrus in the larger-sized farms might be due to the poor heat detection practices because of their large number of dairy animals. The reduction of placenta retention to zero percent in large-sized farms could be associated with improved feed management. The general variations in the occurrences of reproductive disorders among the studied farm scales were due to the differences in management and genetic blood level of cows kept in each farm. These results are in agreement with previous findings of Tesfaye and Shamble (2013), who reported the variation in the prevalence of major productive disorders in the dairy cows due to the differences in management and breed of the animals as well as environmental factors. Therefore, more extension efforts are required to educate the farmers on optimum feeding protocols as well as proper reproductive management of dairy animals to realise higher milk productivity.

Conclusions

In the study area, the majority of dairy farmers were used feed which is below the point of biological and economic optima. This study revealed improved milk production and reduced reproductive disorders at the different levels of dairy farms through the involvement of professionals with regular technical advice and feed optimization. Therefore, efforts should be undertaken to educate the farmers on the balanced feeding of dairy animals for improved dairy production in the study area.

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