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An evaluation of a pilot herd-health programme for improved health and productivity of smallholder dairy herds in peri-urban Kampala, Uganda

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A pilot herd-health programme for improved health and productivity of peri-urban dairy herds in Kampala, Uganda was evaluated. A total of 15 herds were enrolled on the program following informed owner consent. Fortnightly, each herd was visited for a general herd evaluation with data captured using standard evaluation form. Following each visit and for every farm, a herd health report was produced with specific recommendations. The herds (5-10 milking cows) fed on freshly cut Napier (Pennisetum purpureum) generally produced 10 L or less of milk per cow per day. Daily milk production per cow tended to be higher (t=4.386, p<0.05) in farms with larger herd sizes. Herds on commercial dairy meal (DM) supplementation had higher milk production than those on brewer's grain (t=-4.166; p<0.05) or maize bran (t=-4.562; p<0.05) supplementation. We observed no association (t=0.755, p>0.05) between daily milk production and the fortnightly herd health visits. However, following the visits, milk production increased in cows on supplementation with brewer's waste (t = 2.367, p<0.05) or maize bran (t=2.550, p<0.05), and those that had clinical lameness (t=-2.001, p<0.05). In conclusion, peri-urban dairy herds in Uganda are producing below potential because of feeding and disease control challenges. Therefore, strategic interventions for dairy development should emphasize farmer support to improve the feeding of cows but also the control of diseases, especially lameness and east coast fever.

Key words: Herd-health, smallholder dairy, peri-urban, Uganda.

INTRODUCTION

Dairy production is an important and growing sector of Uganda's economy, contributing about 3% of gross

domestic product (GDP) and up to 10% of total agricultural output (EADD, 2008). However, production is characteristically low-input with herds raised largely on pastures and minimal to no feed supplementation (Fonteh et al., 2005). Thus, dairy herds in Uganda produce below potential, with a cow usually producing approximately 10 L or less of milk per day (Fonteh et al., 2005). In extensive pasture-based systems, such low level of production is considered efficient because limited inputs are used in production. However, in intensive high input dairy production systems, higher daily milk yield per cow is required to ensure profitability of the farms (Vellinga et al., 2011). Such herds require sufficient quantities of nutritious pasture supplemented with a balanced dairy ration (Yilmaz et al., 2020). Furthermore, economic efficiency of dairy herds is often dependent on reliable dairy herd-health programmes (Kossaibati and Esslemont, 1997). However, these approaches to dairy herd management are used mainly by established commercial dairy farmers.

Smallholder dairy production is an important economic activity in metropolitan Kampala (Katongole et al., 2012). Unlike established commercial farmers, smallholders find it too costly to provide balanced high-quality rations to their herds (Katongole et al., 2012). They, thus, tend to utilize readily available but unprocessed residues such as maize bran (BR) or brewer's (spent) grain (BW) as alternative feed supplements for milking cows (Chanie and Fievez, 2017). Overzealous feeding of grain products to improve milk production has been associated with high incidence of laminitis, a leading cause of debilitating lameness in dairy cattle (Nocek, 1997). Besides mastitis and infertility, lameness is today considered the most important cause of production losses in intensive dairy systems (Ozsvari, 2017). Thus, working with smallholder farmers to improve utilization of the readily available bran or brewer's waste as feed supplements to lactating dairy cow cannot be overemphasized.

Besides the challenges with feeding, dairy smallholders are also usually not well supported by extension services (Gertzell et al., 2021). They are often dependent on case-based interventions where a veterinary practitioner (usually ambulatory), waits and responds only to calls by farmers with sick animals, and his or her role stops at attending to the sick animal. This is unlike herd-health where regular scheduled visits are made to holistically assess and give advice or intervention on health, welfare and productivity of herds (Mulligan et al., 2006; Nwanta et al., 2011). Herd-health and productivity monitoring programmes are thus, a mainstay of profitable dairy production systems in developed economies (Kossaibati and Esslemont, 1997). We expected a strong association between programmed herd health visits and gradual improvement in health and productivity (milk yield) of the smallholder dairy herds in peri-urban Kampala that participated in the programme.

MATERIALS AND METHODS

Study area

A dairy herd-health programme was developed and evaluated in the peri-urban areas of Kampala, Uganda (Figure 1). The pilot programme was implemented on smallholder farms currently served by the Large Animal Clinic (LAC) of the Department of Veterinary Pharmacy, Clinical and Comparative Medicine, Makerere University, Kampala, Uganda. Some of the farms were within Kampala (00°18′49″N 32°34′52″E), the commercial and administrative capital of Uganda. Most farms were from the surrounding districts of Wakiso (00°24′N 32°29′E) and Mukono (00°28′50″N 32°46′14″E) which are part of the greater metropolitan Kampala.

Study design and selection of study farms and animals

The study animals were stall-fed (zero-grazed) dairy cattle in peri-urban communities in Kampala, Uganda. A herd was selected based on the following criteria: a) had at least 5 milking cows, b) was located within a 30 km radius from Makerere University campus, and, c) the farmer granted informed consent. Based on these criteria, a total of 15 herds were enrolled to participate in scheduled herd-health visits (Mulligan et al., 2006) to support smallholder dairy farms in and around Kampala City, Uganda. Thus, a longitudinal research design was adopted (Ployhart and Vandenberg, 2010). Data collected in the first herd health visit was used as baseline for comparison with subsequent visits.

Data collection

On enrolment, each herd was visited every fortnight for a herd health evaluation (Mulligan et al., 2006). A total of 10 visits were made between March- July, 2020. We adopted a participatory action research approach (Baum et al., 2006). At each herd visit, examination of available health and production records were undertaken. After examination of the records, a general clinical assessment of the herd was undertaken. This involved herd inspection to identify overtly sick animals for physical examination, especially those with clinical lameness (Desrochers et al., 2001). Using California Mastitis Test (CMT), the cows were screened for sub-clinical mastitis (Ferronatto et al., 2018).

Milk samples from cows with clinical mastitis were subjected to culture and antimicrobial sensitivity testing using the agar disc diffusion method on Mueller-Hinton agar plates (Benkova et al., 2020). The Muller-Hinton agar with blood was used for the culture of streptococci. A herd-health report (Fetrow, 1993) was prepared with recommendations for improved health, welfare and productivity for the herd. The printed report was issued days after or during the subsequent visit where the team discussed the recommendations with the farmer and mutually agreed on the on-farm interventions for improved flock health, welfare and productivity. Some of the recommendations in the herd health reports were based on performance standards/references presented in Table 1.

Statistical analysis

Baseline data was collated and descriptive statistics were generated using the frequency functions of Excel (MS Windows, 97-2003). For the purpose of this study, the herd sizes were categorized as small (up to 5 milking cows), medium (6-20 milking cows) or large (>20 milking cows). A generalized linear mixed effect

Figure 1. Map of Uganda showing Kampala metropolitan area.
Retrieved 6th August, 2021 from https://infrastructuretransparency.org/cost-impact-wakisodistrict/

model (GLME) was constructed with milk yield per cow per day as the response (dependent) variable, and feed supplementation, herd lameness, sub-clinical mastitis and scheduled herd health visits as fixed (independent) variables (Crawley, 2013). Since each farm was assessed following 10 consecutive fortnightly visits, the farm identity was considered a random factor in the GLME models (Bates et al., 2014). Being a longitudinal study, baseline data (first/initial visit) was used as reference/control for comparing changes in milk production, lameness and mastitis following repeated herd health visits. Mean variations form the likelihood tests (t-values) were tabulated at 95% confidence level (p≤0.05).

RESULTS

Dairy herd characteristics and feeding practices

A total of 159 cows in 15 participating herds were involved in the pilot herd-health programme. The farms (100%) had Holstein Friesian or their crosses as milking cows. Some herds however, had other breeds besides the Friesen (Table 1). The herds (86%) were small to medium (5-20 milking cows) in size. Daily milk yield was 10 L or less per cow in most (53%) herds. Freshly cut

Napier (*P. purpureum)* grass (75%) was the main forage fed, though some farmers used hay (45%) or silage (15%). Maize bran (75%) and brewer's (spent) grain (45%) was fed in unspecified amounts to supplement pasture feeds.

Record of common diseases, tick control and antimicrobial susceptibility profile on farms

Available on-farm clinical/treatment records showed that 80% of the herds had had at least a case of East coast fever (ECF) by the time of this study. Likewise, 40% and 15% of the herds had clinical records of lumpy skin disease (LSD), foot and mouth disease (FMD), and brucellosis, respectively. In at least 85% of the herds, the status of brucellosis, tuberculosis and mastitis was unknown. Herds were vaccinated against East coast fever (45%), and foot and mouth disuses (15%) only (Figure 2). The control of ectoparasites, especially ticks on most (70%) farms was through weekly application of pyrethroid-organophosphate co-formulated acaricides

Table 1. Dairy herd characteristics and feeding practices.

Herd characteristic	Categories	Percentage of farms (%)	Recommended/standard
Breed of milking cows (had at least 1 animal of the breed listed)	Holstein Friesen	100	All except Ankole (Kugonza et al., 2011*)
	Jersey	30	
	Guernsey	40	
	Ayrshire	5	
	Ankole	10	
Number of milking cows	Up to 5 milking cows	33	>5cows (Krpalkova et al., 2016**)
	06-20 milking cows	53	
	More than 20 milking cows	14	
Mean daily milk yield per cow (litres)	Up to 10 litres/day	53	At least 20 litres/day (King et al., 2006***)
	11-20 litres/day	40	
	More than 20 litres/day	7	
Major type of fodder for dairy herds	Fresh Napier grass (cut curry)	75	Fresh Napier, Cloris or brachiaria (Kabirizi et al., 2013****)
	Hay (cloris/brachiaria)	35	
	Crop residues/peels (banana, cassava, potatoes)	30	
	Natural pastures	15	
	Silage (maize, brachiaria)	15	
Supplementary feeding	Branded dairy meal (DM)	20	DM (Yilmaz et al., 2020) but BR or BW on standardisation (Chanie and Fievez, 2017*****)
	Maize/rice bran (BR)	67	
	Brewer's waste (BW)	33	

*Ankole is a dual-purpose breed usually raised in free-range systems, **Milk yield per cow tends to be higher in large-sized herds, ***In the tropics, a well-managed dairy cow can produce more than 20litres per day, ****Napier (*P. purpureum*) is a high yielding palatable fodder that may be supplemented with Cloris or Brachiaria hay or silage, *****Higher milk production requires supplementation with additional energy, protein, vitamins and minerals that can be provided together by supplements such as dairy meal but smallholders could use other component sources, such as bran or spent Brewer's waste, sunflower meal and a mineral mix.

(Figure 3). Sstaphylococcus (58%) was the commonest bacteria isolated from milk samples and were susceptible (75%) only to cephalexin (Figure 4).

Association between supplementation and lameness occurrence and milk yield

Table 2 summarizes the association between supplementation, mastitis, lameness, herd size and scheduled visits on daily milk production. Cows on commercial dairy meal (DM) produced on average 15 L/cow/day while those on bran or brewer's waste supplementation produced on average 10 L/cow/day. Milk yield was thus, higher in cows on commercial dairy meal than those on brewer's waste (t = -4.166; p <0.05) or maize bran (t = -4.562; p<0.05).

Lameness was highest (about 35%) in herds on brewer's waste supplementation compared to those on maize bran (7%) or commercial dairy meal (<1%).

Lameness did not appear to have significant (t = 0.9200; p >0.05) association with herd daily milk yield. Mean herd prevalence of sub-clinical mastitis (SCM) was about 35% at baseline but steadily decreased to about 12% by the 10th Visit. However, mastitis prevalence was not associated (t = 0.0064, p>0.05) with milk yield. Herd health visits improved daily milk yield of herds on BW (t = 2.3695; p<0.05) and BR (t = 2.5498, p<0.05) supplementation. The prevalence of clinical lameness in herds reduced with repeated visits and the lameness reduction was associated (t = -2.0098; p <0.05) with improved daily milk yield of dairy herds. Finally, there was decrease in herd prevalence of SCM following herd health visits. This however, had no association (t =-
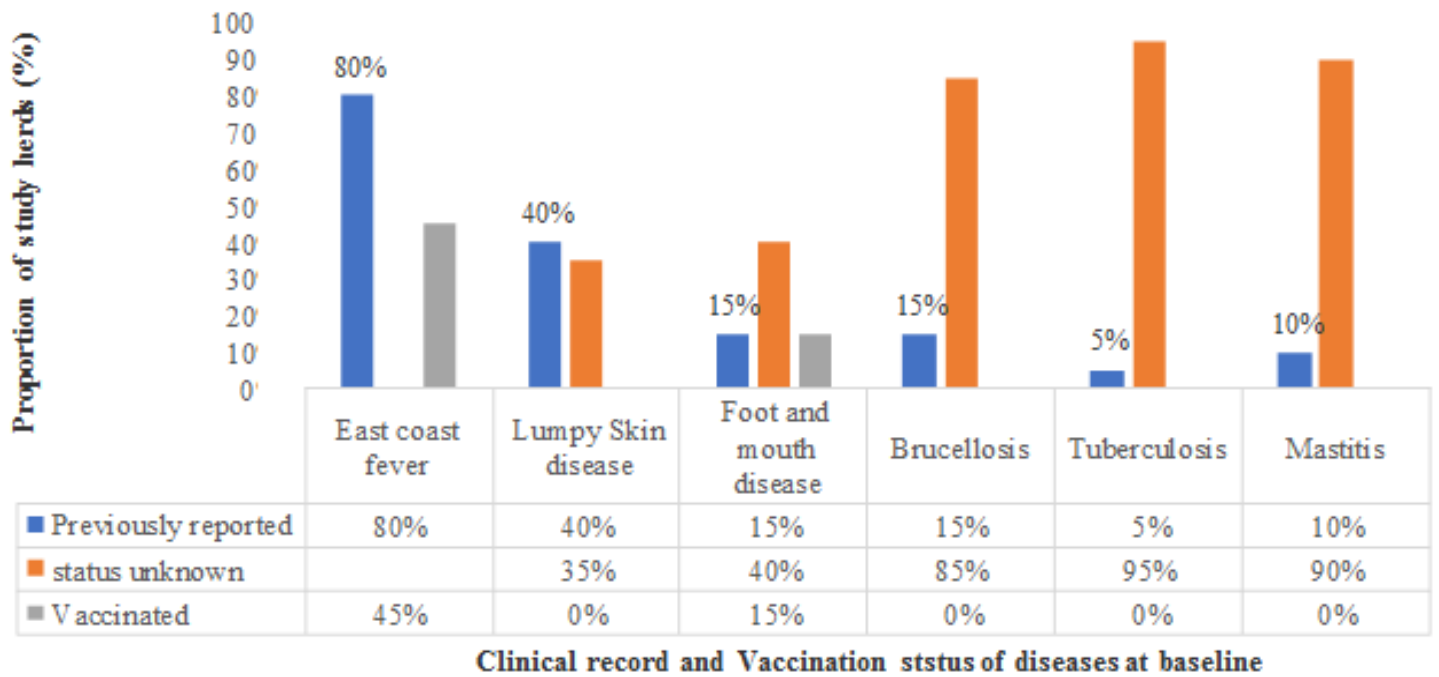
Clinical record and Vaccination ststus of diseases at baseline					
	East coast fever	Lumpy Skin disease	Foot and mouth disease	Brucellosis	Tuberculosis	Mastitis
Previously reported	80%	40%	15%	15%	5%	10%
status unknown		35%	40%	85%	95%	90%
Vaccinated	45%	0%	15%	0%	0%	0%

Figure 2. On-farm clinical records and vaccination status of herds at baseline.
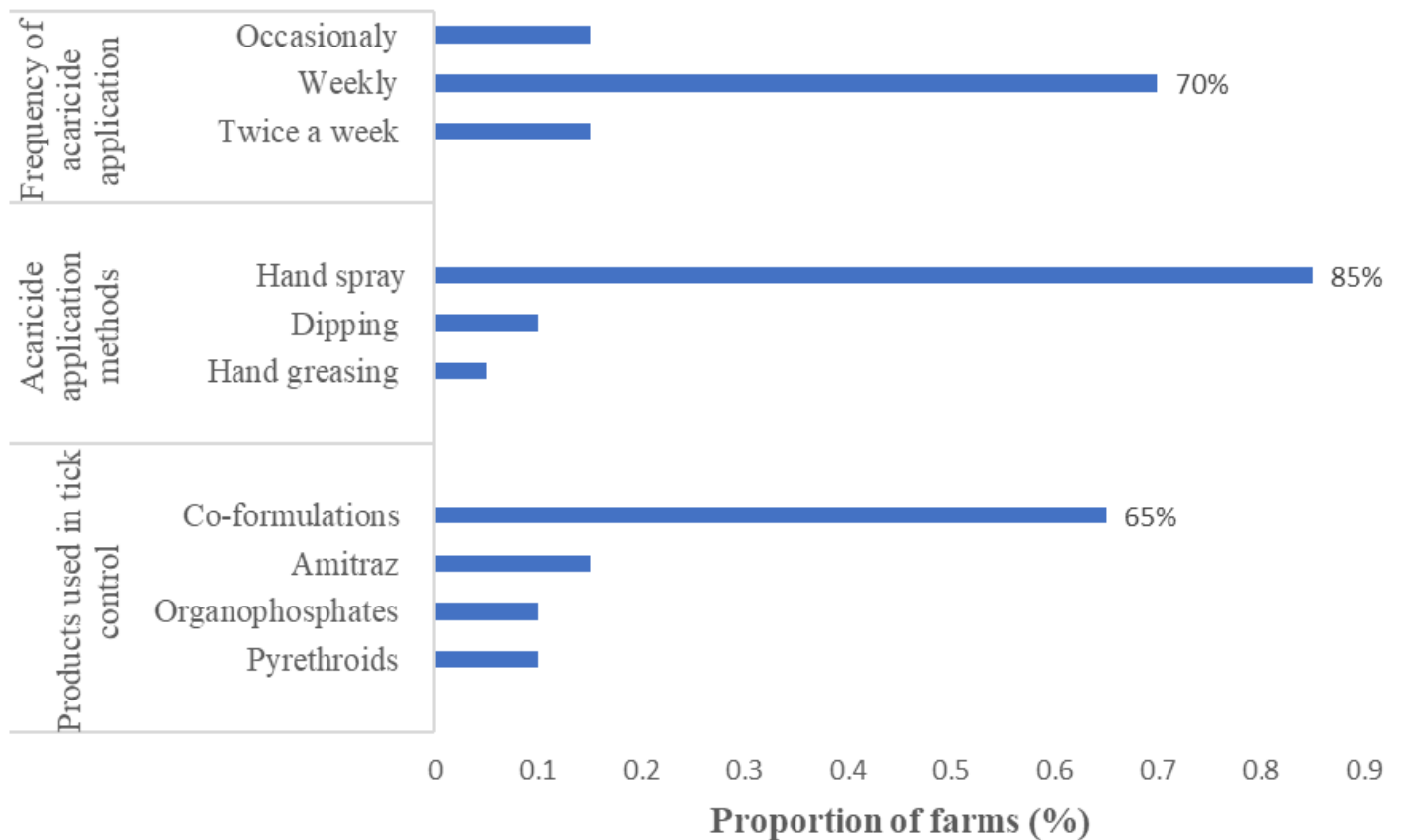

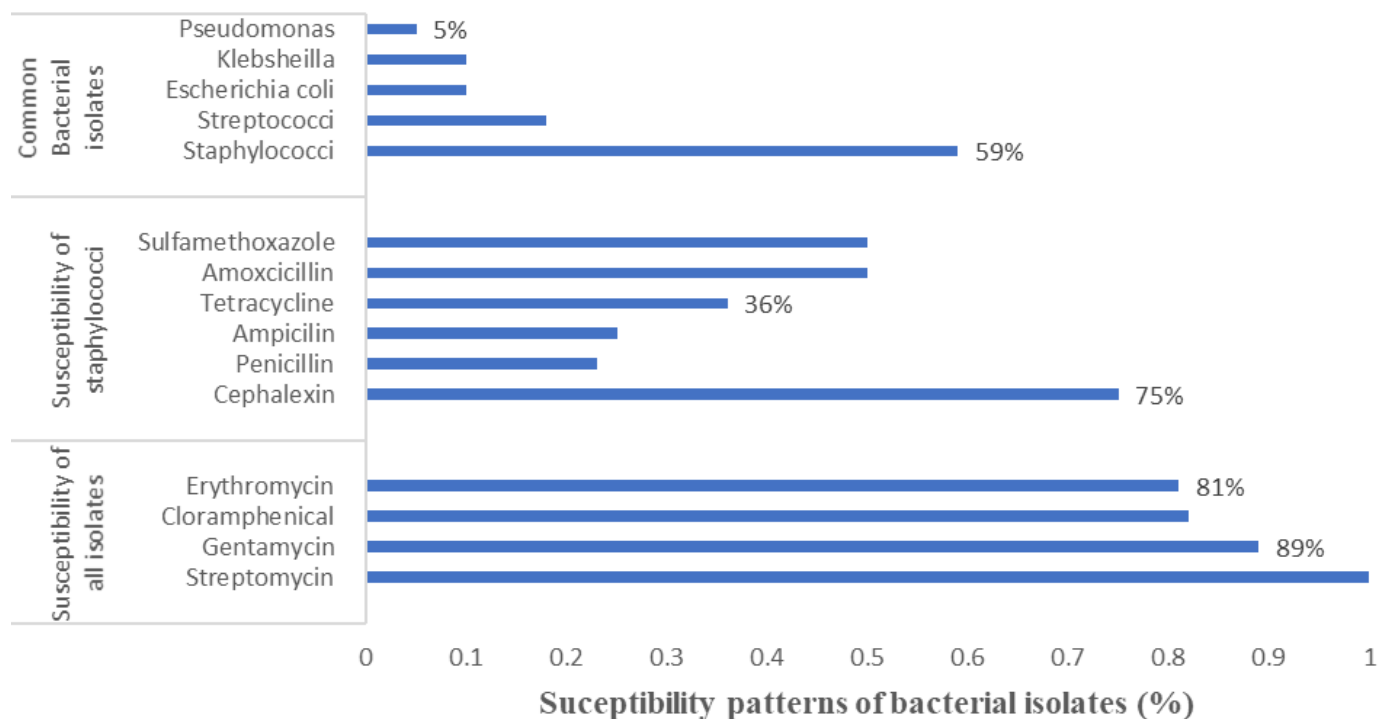**Figure 3.** Tick control practices on the dairy farms.

Figure 4. Antimicrobial susceptibility of bacteria isolated from milk samples.

Table 2. Association between herd supplementation, lameness, mastitis and milk yield.

Fixed effect	Estimate	SE	DF	t-value	p-value
Intercept	15.5810	1.6530	125	9.4230	<0.0000
Supplement: Brewer's waste (BW)	-4.6380	1.1260	125	-4.1660	0.0001*
Supplement: Maize bran (BR)	-4.0210	0.8810	125	-4.5620	<0.0001*
Sub-clinical mastitis (SCM)	-0.0001	0.0120	125	0.0064	0.9915
Herd lameness	0.0185	0.0200	125	0.9200	0.3592
Size of milking herd	-0.2519	0.0570	125	-4.3860	<0.0001*
Scheduled herd health visit (HHV)	0.9000	0.1992	125	0.7552	0.4515
HHV and BW	0.4824	0.2036	125	2.3695	0.0193*
HHV and BR	0.3016	0.1183	125	2.5498	0.0120*
HHV and SCM	-0.0038	0.0023	125	-1.6766	0.0916
HHV and herd lameness	-0.0072	0.0036	125	-2.0098	0.0466*

*Significant difference (p<0.05).

1.6766, p>0.05) with daily milk production of the herds.

DISCUSSION

All of the farmers kept the Holstein Friesian or its crosses. A study by Fonteh et al. (2005) reported a similar finding. They described a model peri-urban smallholder dairy farm in Uganda typically as "*one to three milking cows of exotic breed (particularly Holstein type) are located in a stable and the management style is of the intensive type*'. The Holstein is often preferred because of its higher milk production compared to other dairy breeds (King et al., 2006) or the Ankole (Kugonza et al., 2011) which is mostly raised as a dual-purpose breed in a free-range setting. Thus, the preference by farmers should inform major interventions aimed at genetic improvement of dairy cattle productivity in Uganda.

In this study, most (86%) herds were small (5 or less milking cows) or medium (6-20 milking cows) sized. Fonteh et al. (2005), reported similar findings in a study to characterise dairy production in the Lake Victoria crescent. They argued that keeping small dairy herds is dictated by the small land holding by peri-urban families, who on average, own just an acre or less of land. Because of this, stall feeding is the most suitable and popular cattle-rearing system in per-urban Kampala (Katongole et al., 2012). Indeed, land fragmentation is worsening given the rapid growth of population and urbanisation in the region thus limiting opportunities for expansion of peri-urban dairy farms (Katongole et al., 2012).

For most (53%) of the herds, daily milk production per cow was 10 liters or less. Fonteh et al. (2005) similarly reported that stall-fed cow in peri-urban Uganda produces just under 10 L of milk per day. They reasoned that low milk production in the current dairy production systems in Uganda is because very few inputs are allowed into the system while a lot of products are sent out, thus creating an imbalance that render dairy productions systems less productive. A related study later recommended that farmers should introduce high yielding varieties of nutritious fodder (Kabirizi et al., 2013). This in addition to acquiring better knowledge and skills in intensive dairy cattle production, especially in feeding dairy cows for higher milk production (Kabirizi et al., 2013). It is evident therefore, that smallholder dairy farmers in peri-urban Kampala still need sustained extension, such as herd health programs for better animal nutrition and improved herd productivity.

From the farm records, East Coast Fever (ECF) was reported on 80% of the 45 herds surveyed at baseline. In a retrospective laboratory-based study, Byaruhanga et al. (2017) reported about the same prevalence (92.9%) in clinical samples submitted to a diagnostic laboratory in Makerere University, Uganda. Other earlier studies indeed confirmed that (ECF) is the most prevalent and economically devastating disease of cattle in Uganda (Ocaido et al., 2009; Vudriko et al., 2016). The disease is estimated to be responsible for nearly 90% of total disease control expenditure on farms, besides causing 30% calf-crop mortality (Ocaido et al., 2009). This finding may explain why farmers, especially in extensive grazing systems, are reluctant to introduce taurine dairy breeds but rather keep the less productive indigenous cattle, such as the Ankole breed (Kugonza et al., 2011). In this study, we observed that farmers were applying acaricides weekly for tick control. This application rate has been implicated in causing the current problem of tick acaricide resistance in Uganda (Vudriko et al., 2016). Therefore, strategic interventions for improved dairy development in Uganda should emphasize sustainable control of ticks and tick-borne diseases, especially east coast fever.

Other diseases reported were foot and mouth (FMD) and lumpy skin (LSD), both transboundary animal diseases (TAD) that have gained endemicity in Uganda (Kerfua et al., 2018; Ochwo et al., 2019). In view of Uganda's growing milk exports, effective control measures against the TADs should be instituted at a national level to ensure safety of products currently being exported.

Staphylococci isolated from clinical mastitis cases were 75% susceptible to cephalexin but generally less than 50% susceptible to other antimicrobials (tetracyclines, penicillin and sulphonamide antimicrobials). An earlier report by Byarugaba (2004) noted that there is a high prevalence of antimicrobial resistance in Uganda with equally high possibility of cross-resistance between livestock and humans. This problem has been attributed to rampant use of antimicrobials in livestock production (Byaruhanga et al., 2017). Form this preliminary evidence, it is advisable that elaborate systemic studies be conducted to implore sustainable strategies for effective mastitis control given that antimicrobials for treatment are generally ineffective.

Most herds were supplemented on maize bran (75%) or brewer's (spent) grain (45%). This is similar to findings from previous studies on dairy cattle feeding in peri-urban Kampala (Okwee-Acai et al., 2004; Katongole et al., 2012). Okwee-Acai et al. (2004) particularly noted that brewer's waste is often fed in excessive quantities, and they associated this practice with the observed high incidence of laminitis amongst dairy cows. They argued that farmers lack knowledge on efficient utilization of bran and/or brewer's waste for improved milk production. Excessive intake of carbohydrates (grain overload) is the leading cause of claw lesions and associated production losses in intensive dairy management systems (Nocek, 1997). Therefore, peri-urban smallholder dairy producers in Uganda still require sustained training and provision of technical information on rational utilisation of readily available grain resources for improved dairy production.

In this study, we noted that milk yield was higher in cows on commercial dairy meal than those on brewer's waste (t = -4.166; p <0.05) or maize bran; BR (t = -4.562; p<0.05). Though pre-liminary, this observation augments the long-held principle that on dairy farms, nutritional management, including rational grain feeding is the most important determinant of herd productivity (Chanie and Fievez, 2017; Yilmaz et al., 2020). This is why dairy herd health practitioners often work with individual farmers to promptly identify and address on-farm health, welfare and husbandry challenges, including nutrition (Mulligan et al., 2006; Butler et al., 2008). Herd health practice is the default extension approach in highly developed dairy production systems globally (Kristensen and Jakobsen, 2011). Although a controlled trial is needed to provide stronger evidence, it can be suggested from the current findings that development of intensive dairy production in Uganda still needs a sustained farmer education. The

sustained extension could particularly take a herd health approach to improved dairy cow nutrition for higher herd productivity.

There was decrease in herd prevalence of SCM following herd health visits. This however, had no association (t=-1.6766, p>0.05) with daily milk production of the herds. This result, suggests that though prevalent, sub-clinical mastitis did not directly cause production losses. The finding agrees with Dillon et al. (2015) who reported that in dairy cattle herds, productivity losses associated with sub-clinical mastitis is usually about 2% only. They noted that control measures to reduce the prevalence of sub-clinical mastitis are not aimed at improving production *per se* but are quality measures to meet quality standards (the required somatic cell count) at bulking centres. Most significant losses due to SCM results from milk rejection at bulking centres or processing plants where quality standards are enforced (Sharif and Mohammad, 2009). Such rejections cause farmers to enforce strict mastitis control measures such as regular screening, teat dipping and dry-cow therapy (Sharif and Mohammad, 2009). The treatment and control measures instituted that are responsible for nearly 80% of economic losses attributable to mastitis (Dillon et al., 2015). In Uganda, peri-urban smallholder farmers sell raw milk directly to neighbours or nearby trading centres where quality standards are not enforced (Kirembe, 2000). However, this result points out the potential of herd health in ensuring herd level reduction in mastitis prevalence which is essential in production of wholesome and quality milk.

Lameness was highest (about 35%) in herds on brewer's waste (BR) supplementation compared to those on maize bran (7%) or commercial dairy meal (<1%). However, with repeated visits, the prevalence of herd lameness steadily declined while milk yield significantly (t = -2.0098; p <0.05) increased. A survey by Okwee-Acai et al. (2004) earlier established that feeding of brewer's waste to zero-grazed dairy cows in Uganda strongly predisposed to the occurrence of claw lesions and lameness. They emphasised the need for a sustained farmer education to ensure rational utilisation of highly fermentable carbohydrate feed resources such as brewer's waste. Lameness, mastitis and infertility, the so-called dairy production diseases, are traditionally known to be the leading causes of production loses in dairy herds (Kossaibati and Esslemont, 1997; Hogeveen et al., 2019). Undoubtedly, economic efficiency of intensive dairy production depends largely on effective control of production diseases, usually through herd health programs (Mulligan et al., 2006).

Conclusion

Although a controlled trial is needed to provide stronger evidence, overall, we conclude that peri-urban dairy herds in Uganda are producing below their potential due to on-farm challenges of nutrition and diseases such as East coast fever. Therefore, strategic interventions for dairy development in Uganda should emphasize farmer support for improved dairy cow feeding and the control of disease conditions such as lameness and east coast fever.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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