Dairy village: the role of veterinary services in unlocking dairy industry potential through assisted reproductive technologies

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Abstract

The "Dairy Village" concept was designed to overcome the constraints of estrus synchronization and AI particularly associated with seletion of the breeding animals and subsequent management of estrous cows in Ethiopia. All necessary inputs, including sexed semen, were acquired before the fieldwork. The knowledge and skill gaps were identified and addressed with the active involvement of veterinarians and AI technicians who underwent specialized training to ensure proper physical and gynecological examinations during the selection of cows and heifers. Accordingly, a refresher training was delivered on topics of reproductive anatomy and physiology, assessment of ovarian status, semen handling, and insemination at the optimal time to establish pregnancy. Besides, awareness creation seminars were held every year on topics of benefits of reproductive technologies and management of breeding cows to 99 smallholder dairy farmers. Only 578 cows/heifers were found fit for breeding out of the 1262 cows/heifers that were brought for evaluation; including 81 animals that spontaneously showed estrus. A total of 497 cows/heifers were synchronized using a single IM injection of Lutalyse. Animals responding to the treatment (404 cow/heifers) and those spontaneously in estrus (81cows/heifers) were inseminated using sex-sorted HF semen 18-24hrs into the standing estrus. Pregnancy rate was 80% (388/485) and 287 calves were born (96% female). Results of this project indicate that rigorous gynecological examination during the selection of cows prior to estrus synchronization and judicious application of hormonal treatments can yield improve the success of ES/AI projects under field conditions. Furthermore, the dairy village approach to en-

hanced milk production through efficient use of sex-sorted semen has generated replacement heifers from superior breed that will substantially improve the livelihoods of village farmers.

Keywords: Artificial Insemination; Dairy village; Estrus synchronization; Genetic improvement; Sex-sorted semen.

Introduction

As the growth of the human population increases, so does the demand for food, particularly for nutritious animal-source foods such as milk and meat (WFP and CSA, 2019; Dror and Allen, 2011). Although Ethiopia has a massive livestock population, there is a mismatch between livestock numbers and quantities of livestock products due to low individual animal productivity' (FAO, 2018; CSA, 2020/21). Hence, meeting the steadily increasing demand for nutritious food like milk, is possible only by increasing individual/herd-level productivity through proper management of improved dairy breeds. Nevertheless, despite the great effort made, the use of artificial insemination (AI) and estrus synchronization (ES) has had a trivial impact dairy cattle genetic improvement through crossbreeding with exotic breeds (Hunde, 2018). Hence milk production in Ethiopia remains low and inefficient (Desalegn, 2009). Several possible interventions have been identified to remedy this situation, including culling unproductive animals and decreasing herd size to retain only highly productive animals. This has significantly enhanced reproductive management (because pregnancy and birth are required to initiate milk production); and increased herd/individual productivity through improved genetics and subsequently reduced headcount with the help of biotechnology tools (LGA, 2016; Tegegne *et al.,* 2016; FAO, 2017; Adegbola *et al.,* 2020; Daba *et al*., 2022). As intensification is becoming the best option to cope with scarcity of grazing land, there is currently a high demand for improved dairy cows on the market. The exorbitant prices became unaffordable for smallholder farmers, and the importation of live cows/heifers from other countries is also unlikely due to unaffordable prices. Therefore, a more rational application of technology, knowledge management, and service delivery system are needed to increase productivity and operational effectiveness.

Field application of reproductive technologies in dairy cattle demands skillful assessment of the suitability of anatomy and physiology of cows presented for breeding, judicious implementation of ES protocols, proper detection of estrus, appropriate semen handling, and correct timing of insemination. One of the suggested solutions for this in Ethiopia has been the adoption of a “Model Dairy Village”. Two reasons make this essential: increasing the operational efficiency of reproductive technologies in community services, and facilitating the adoption of livestock biotechnologies. AI practices augmented with the use of sex-sorted semen would enhance genetic improvement and further improve subsequent animal/herd productivity. The main objective of this article is to share the best practices that evolved during the implementation of the “Model Dairy Village” approach aimed at increasing the production of female calves with superior genetic capacity for milk production. This approach was implemented for three years using ES and AI with sex-sorted semen.

Materials and methods

Description of the study areas

The study was conducted in selected kebeles found in the East Shewa Zone of Ada’aa woreda of Oromia Regional state, namely Denkaka, Ude, Akaki, and Bishoftu towns of Bishoftu City Administration. The study area, Bishoftu, is located at a 45 km distance from Addis Ababa in the South. The area is located at 9°N latitude and 40°E longitude at an altitude of 1850 m with annual rainfall of 866 mm, of which 84% is in the long rainy season, June to September. The annual average temperature ranges from 12.3^{o}C to 27.7^{o}C with an overall average of 18.7^{o}C. It is an important town where most governmental institutions, including national and international research centers, are located. Cattle, small ruminants, poultry, swine, and equines are the major livestock species kept with fast-growing small-scale dairy production (NMSA, 2010). As Ada’aa is known for its mixed crop-livestock farming systems, Teff, westrus, and legumes are major crops produced in the study area.

Study population

A total of 99 smallholder farms comprising 1262 zebu and zebu*HF cross-bred cows/heifers were included in the pilot study. The cows/heifers were selected for breeding after passing a rigorous clinical and gynecological evaluations. Only those that were apparently healthy, cycling and with a CL on their ovaries were enrolled into the estrus synchronization (ES) and AI project.

Review of previous practice and identification of intervention loop

During the early stages of the "Model Dairy Village" concept, a questionnaire was administered to 99 dairy producers. Additionally, researchers with multidisciplinary expertise were involved in the field implementation of the technology. A total of five animal health and reproductive biotechnology researchers from Debre Zeit Agricultural Research Center and 35 experts (6 AI technicians and 29 animal production experts) from Ada'aa livestock and fishery sectors developmental agents who had previously participated in ES and AI projects were involved in the study. The experts initially made assessment of the main limiting factors that adversely affected previous efforts in the identified pilot sites. A predesigned data collection format consisting of quires on breed, parity, cyclicity, sire ID, calf sex, and BCS was used for recording.

Previous field implementation reports of ES and AI efforts undertaken in different regions of Ethiopia were also reviewed, and four major areas of interventions were identified to circumvent the factors that rendered the previous ES and AI service delivery system inefficient.

- Creating awareness of the dairy farmers regarding needed technological inputs and the critical role of the animal owners in the success of ES and AI procedures
- Reducing the knowledge gap among AI technicians with regard to a) bovine reproductive anatomy and physiology, and b) selection of physically and physiologically "fit" animals presented for ES and subsequent AI
- Provision of inputs and supplies to ensure that supply limitations would not hinder success
- Practical engagement veterinarian, reproductive technology researchers, and trained AIT in field application

Awareness creation and refreshment training

Training was given to the selected farm owners (n=99) to create awareness on bovine estrus and management of breeding cows (Figure 1). The dairy experts (n=29), and AI technicians (n=6) were also given theoretical (25% of allotted time) and skill (75% of allotted time) refresher training on bovine reproductive anatomy and physiology, skills of determining ovarian status, proper semen handling and insemination techniques for use with sex-sorted semen, gynecological evaluation, estrus synchronization, AI and pregnancy diagnosis (Figure

2). The trainees were expected to implement the knowledge and skills captured through this training during the field application of this pilot work.

Figure 1. Awareness creation seminar for the farmers in Bishoftu City and Dankaka dairy village

Figure 2. Theoretical and practical training on AI and gynecological evaluation at DZARC

Selection of animals for the ES and AI project

A total of 1262 cows/heifers those were presented as potential candidates underwent a thorough clinical and gynecological examination by the trained experts to determine their suitability for enrollment into the ES and AI demonstration project. Only 578 cows/heifers (45.8%) including 81 cows/heifers that showed natural estrus, were considered fit for breeding based on BCS (≥ 2.75 on a 5 scale) and the presence of an active CL. Cows/heifers that did not show natural estrus (n=497) received a single IM injection of Lutalyse® (Dinoprost tromethamine, equivalent to 5mg per ml dinoprost, Zoetis Inc, Kalamazoo, Spain). Estrus was observed visually by the trained owners and 404 cows/heifers (81.3%) responded to the Lutalyse treatment. A total of 485 cows/heifers (both the induced and natural) were inseminated with Holstein breed sex-sorted semen (ABS Global, Inc. USA; BUTZ-HILL MOOGENE-ET, Reg.# 71088738 and DEEP-RUN-CRK DFR CANYON-ET, Reg#73855681) 18 to 24 hours after the start of standing estrus. Pregnancy was diagnosed 70 days post AI via transrectal palpation.

Results

Review of previous reports

Some of the numerous challenges reported to impede the previous ES and AI success were a lack of understanding of the concept of ES by extension personnel, experts, and farmers, lack of proper selection of animals suitable for ES and AI based on body condition score and/or reproductive tract status; poor estrus detection by farmers; inadequate preparation for the provision of the AI service; poor technical capacity and lack of experience by AI technicians (AIT); and weak support from administrative bodies. Furthermore, 77% of the farmers were not aware of the ES and AI technologies. Only 17% were aware and satisfied with the ES and AI achievement. None of the farmers participated in awareness-creation seminars on ES and AI technologies. All AIT and experts did participate in similar training/seminars but never had practical exercise. There were also limitations in the availability of inputs, quality of semen used, and LN2 for regularly topping up the semen tank.

- **Body condition of heifers/cows:** 1.5% of presented animals had BCS < 2.5, 41.2% had 2.5 to 3.0, 30.3% had >3 to 3.5, 24.8% had >3.5 to 4, and 2.2% possessed a BCS >4 (Figure 3).

Figure 3. A cow (left) and a heifer (right) grouped as unfit for synchronization due to poor body condition (BCS <2.5)

- **Estrus response:** From the 497 cows/heifers that received Lutalyse (PGF2α) for synchronization of estrus, 404 (81.3%) showed overt estrus and were presented for AI. The response of the remaining 93 cows/heifers was undetermined because animals didn't return for AI and/or farmers provided no feedback either. Farmers who assigned children to detect estrus or who entirely neglected estrus detection (n=70) failed to get their cows impregnated in a timely manner. Unlike previous reports on mass ES, no cow/heifer aborted after receiving PFG2α in this project confirming the importance of a thorough gynecological exam prior to ES.
- **Pregnancy detection (PD):** the pregnancy rate was 80% (Table 1) with the average services per conception of 1.14 (excluding those animals with no feedback and with a history of repeat breeding). A total of 285 calves were born (including two twin births, Table 2).

Table 1. Pregnancy test results in areas included in mass estrus synchronization by location

Location	PD test result			Total
	Negative	Pregnant	Unknown	
Ada'aa (Denkaka, Ude, Akaki)	47	247		322
Bishoftu	43	113	7	163
Total	90 (18.6%)	388 (80.0%)	7 (1.4%)	485 (100.0%)

Additionally, the rate of abortion, stillbirth, and neonatal death were 3.1%, 0.25%, and 2.8%, respectively. All of the reproductive losses occurred in Holstein or Holstein crosses cows/heifers.

Table 2. Number of female calves born from the ES and sexed semen AI in pilot dairy villages

Location	Gender of calves born		Total
	Female	Male	
Ada'a	182	7	189
Akaki	19	1	20
Bishoftu	722	4	76
Total	273 (95.79%)	12 (4.21%)	285 (100.00%)

Community outreach

Farmers, professionals, development partners, and policymakers were introduced to reproductive technologies and techniques by arranging farmers' field days (Figure 4). During the event, participants were able to see first-hand when ES and AI with sex-sorted semen were successfully applied under field conditions in the target communities. The field days were organized by DZARC in collaboration with the Ada'a district agricultural development office. The level of satisfaction among participant smallholders with the ES and AI project were 45%, 44%, and 7% as excellent, good and fair, respectively.

Figure 4. First batch of newborn calves visited by Minister dE'tat and other zonal higher officials in Dankaka Dairy Village

Discussion

Different research reports from Ethiopia indicate that both ES and AI services are constrained by multiple factors functioning in cohorts, such as poor infrastructure development (Desalegn, 2009), poor feeding management of breeding animals, and rampant disease problems affecting general health and fertility (Tegegne *et al.,* 2016). However, problems of estrus detection, semen shortage, transportation and semen handling issues, unreliable supply of LN_2, and meager skill of AI technicians have long been identified as major limiting factors (Tegegne *et al.*, 2012). The survey that was administered before the field implementation of the "Model Dairy Village" concept confirmed the extensiveness of some of the previously reported problems. In addition, the high proportion of (>50%) cows/heifers failing the evaluation for breeding fitness in the present were mostly because of the poor body condition (41% of cows/heifers were between 2.5 and 3.0) and anestrous. Past performance of scaled-up ES technology in different parts of Ethiopia produced inconsistent results and was deemed as low efficiency (Azage *et al.,* 1989; Gizaw *et al.,* 2016; Mossie and Wondmnew, 2016). The rapid appraisal survey results in the current study showed that the major limitation of ES programs was the lack of or negligence to identify non-cyclic cows/heifers before initiation of hormonal treatment.

The treatment response obtained in this study was in agreement with previous reports (Aydaiso *et al.,* 2020; Shanku, 2022; Haile *et al*., 2023) but relatively higher than rates reported by Fantahun and Admasu (2017) and Gizaw *et al.* (2016). Estrus detection efficiency was one of the major limiting factors for the success of ES programs (Sveberg *et al*., 2011; Roelofs and Van Erp-van der Kooij, 2018), which goes in line with the present report. Prostaglandin F2α and its analogs are effective luteolytic agents capable of inducing regression of the corpus luteum (CL) and are widely used in ES protocols (Lucy *et al*., 2004; Oaxaca *et al*., 2009; Ahlawat *et al*., 2015; Paul *et al*., 2015). In the current work, both natural and synthetic prostaglandin F2α were administered intramuscularly, effectively inducing estrus within 72 hours of treatment.

Limitations in technical skill have been identified to affect AI service in Ethiopia (Desalegn, 2008; Tegegne *et al.,* 2016; Gizaw *et al.,* 2016). In this study, the refresher theoretical and skill training has greatly impacted the ability of the AI technicians to make decisions and correctly recruit animal fit for breeding (cycling and with active CL on the ovary). Owing to this and accurate detection of estrus has improved both the service per conception and conception rate even with sex-sorted semen. The absence of abortion after PGF2α treatment for ES supported the effectiveness of the training in accurately identifying the physiological status of cows/heifers during gynecological examination. Current findings also proved a high degree of effectiveness of a single-shot prostaglandin-based ES protocol if proper CL identification and estrus detection occurred. The proportion of female calves born in this project (96%) was higher than the vendor's claim (company recommendation, which is about 90%).

Conclusions

Successful implementation of an ES protocol requires the selection of cows/heifers based on their BCS and knowledge of their ovarian status before administration of prostaglandin F2α. On-job training of AI technicians focused on bovine reproductive anatomy and physiology requires the technical contribution of veterinarians in enhancing the skill and knowledge base of those AITs. The success achieved in this pilot demonstration project of a "Model Dairy Village" was also attributed to having all required inputs and determining the logistics of implementation of ES and subsequent AI with sexed semen. Farmer education to create awareness of bovine reproductive technologies and their proper implementation, coupled with farmers sharing their personal experiences (with ES and AI) with other farmers, was another key to success. The current pilot project unveiled the innovative approach followed in the application of ES and AI with sexed semen for the genetic improvement of dairy cattle. This represents a much-needed and long-overdue technological advancement that can transform the lives of smallholder farmers. Therefore, the recommendations emanating from the current "Model Dairy Village" pilot project are:

- Awareness creation and knowledge transfer are needed to enhance farmers' understanding of ES and AI technologies, which increases their willingness to adopt the technologies.
- Proper nutritional management of cows/heifers to obtain a good body condition score (BCS) is crucial to the success of ES and AI programs.
- Refresher training for AI technicians who are focused on bovine reproductive anatomy and physiology (including identification of ovarian structures via rectal palpation) is essential. Additional training topics should include proper semen handling and insemination technique, timing (especially for sexed semen), and site of artificial insemination, which require active involvement and the leading role of veterinarians to unlock the dairy potential of the country.
- Acquisition of inputs and consumables used for AI service before implementation of ES is vital, as is the logistical planning.
- By implementing ES and AI within a village, community members can share resources among themselves and learn from each other.

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