LIVES WORKING PAPER 16

History and experiences of hormonal oestrus synchronization and mass insemination of cattle for improved genetics in Ethiopia: From science to developmental impact

History and experiences of hormonal oestrus synchronization and mass insemination of cattle for improved genetics in Ethiopia: From science to developmental impact

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February 2016

Editing, design and layout—ILRI Editorial and Publishing Services, Addis Ababa, Ethiopia.

Cover photo—ILRI/Azage Tegegne

ISBN: 92–9146–459–7

Citation: Tegegne, A., Hoekstra, D., Gebremedhin, B. and Gizaw, S. 2016. *History and experiences of hormonal oestrus synchronization and mass insemination of cattle for improved genetics in Ethiopia: From science to developmental impact.* LIVES Working Paper 16. Nairobi, Kenya: International Livestock Research Institute (ILRI).

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Acronyms

AI	Artificial insemination
ARARI	Amhara Regional Agricultural Research Institute
BoA	Bureau of Agriculture
EMDTI	Ethiopian Meat and Dairy Technology Institute
GOE	Government of Ethiopia
GTP	Growth and Transformation Plan
IFD	Improved family dairy
ILCA	International Livestock Centre for Africa
ILRAD	International Laboratory for Research on Animal Diseases
IPMS	Improving Productivity and Market Success
IRR	Internal rate of return
LG	Lowland grazing
LIVES	Livestock and Irrigation Value Chains for Ethiopian Smallholders
LMP	Livestock master plan
LSA	Livestock sector analysis
MoA	Ministry of Agriculture
MRD	Mixed rainfall deficient
MRS	Mixed rainfall sufficient
NAIC	National Artificial Insemination Centre
OARI	Oromia Agricultural Research Institute

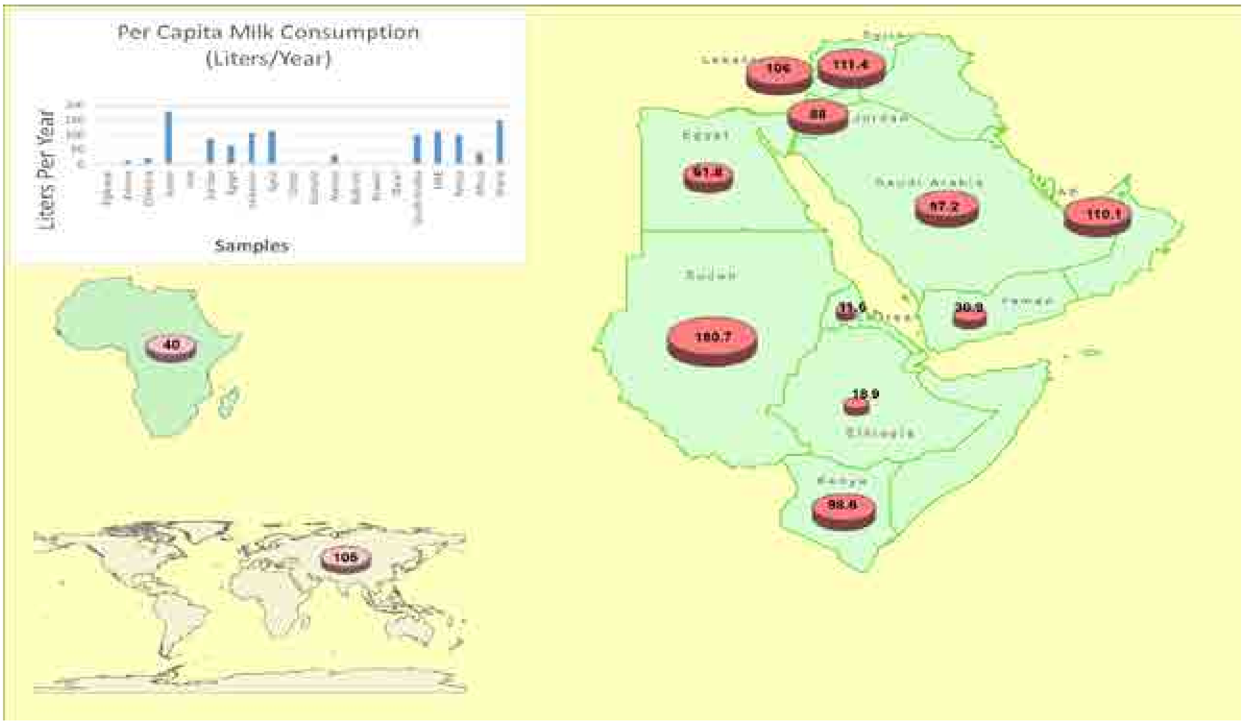
OoARD	Office of Agriculture and Rural Development
PRID	Progesterone releasing intravaginal device
SNNPR	Southern Nations Nationalities and People's Regions
UHT	Ultra heat treated

1. Background

Ethiopia has over 54 million indigenous cattle, and about 11.2 million are breeder cows (CSA 2012/13). The number of improved dairy type animals is insignificant. The production system is constrained by a number of factors. These include subsistence-oriented production system, lack of awareness of improved livestock production system (by farmers, pastoralists/agro-pastoralists, professional and policy and decision-makers), feed resources, animal diseases, markets, etc. The burden of this huge livestock resource is also compromised by the poor reproductive performance, with an annual calving rate of about 45%. Out of this huge number of breeder cows, the annual number of calves born is only about 5.04 million. The remaining 6.16 million cows have to be fed and managed without producing either milk or calves. Again, about 15% of the calves die before attaining weaning age. This is a loss of about 756,000 calves every year. This huge reproductive wastage and pre-weaning calf losses could be averted through improved fertility management and reduced calf morality.

Average milk production from local cows is also low, estimated at 1.32 litres/cow per day (CSA 2012/13). This results in a total annual milk production of 3.81 billion litres and about 50% of this goes to calves. Per capita milk consumption is low and stands at 19 kg/year FAO (2011). This consumption level is extremely low compared to some African and Middle East countries (Figure 1). Due to the high demand-supply variance, annual import of dairy products costs the country over USD 10 million. The current human population of about 90 million will double by 2030; further increasing the demand for milk and milk products. However, Ethiopia has a huge and untapped potential for dairy development due to the large human and livestock population and suitable agro-ecologies. The sector is constrained by a number of factors. Extension service to develop the livestock sector is weak. For example, according to CSA (2012/13), out of the total of 15.5 million livestock holders only 138,000 holders (0.89% of the total livestock holders) were involved in livestock extension packages during the reference period. Out of those involved in livestock extension packages, only 34,056 holders (24.6%) were engaged in dairy development packages; which translates to only 0.22% of the total livestock holders. Another major problem hindering smallholder farmers from participating in milk production and marketing is lack of access to and high price of improved dairy animals. According to the Ministry of Agriculture, although artificial insemination started some four decades ago, the number of crossbred animals produced so far is only about 750,000. In contrast, Kenya, with cattle population of about 12 million, has around three million crossbred dairy cows. One of the key interventions in the development of dairy value chain in Ethiopia is to improve smallholders' access to genetically improved dairy cows in areas where dairy development is feasible.

Figure 1: Comparative data on per capita milk consumption (kg/year).



To address this bottleneck attempts have been made to experiment with private artificial insemination (AI) service delivery, private bull stations and the facilitation of purchase of crossbred heifers. However, although some improvements could be observed, it was difficult to ensure large-scale impact, particularly at smallholders' level. The use of mass insemination in targeted production areas using hormones to regulate the oestrus cycle was considered as a possible alternative option. Since then the Improving Productivity and Market Success (IPMS)/ Livestock and Irrigation Value Chains for Ethiopian Smallholders (LIVES) projects with partners tried and gained experience with mass insemination of cows in different milksheds in Tigray, Amhara, Oromia and Southern Nations Nationalities and People's (SNNP) regions.

Hormonal oestrus synchronization (Tegegne, T. et al. 1989) under smallholder context could be used, among others, to produce large number of dairy animals in a relatively short period of time (kick start), to match calving with feed availability and market demand for dairy products and to improve the effectiveness and efficiency of AI service. Results are promising and the project will continue to assist the national and regional research and development partners in developing programs aimed at a more effective and efficient AI service delivery system. However other production, input supply and processing/marketing interventions (following the value chain approach) should complement the mass insemination intervention to reap the full benefits of developing the dairy value chain in Ethiopia.

This paper is based on the results of testing a simple hormonal oestrus synchronization protocol and mass insemination under on-farm conditions in order to improve access to improved dairy genetics by smallholder farmers and to kick-start market-oriented smallholder dairy development in selected sites. The paper documents the history of oestrous synchronization in Ethiopia and experiences of the IPMS (www.ipms-ethiopia.org) and LIVES projects (www.lives-ethiopia.org) and partners in testing and implementing this innovative approach. While the approach was first tested in the fluid milksheds in urban and peri-urban areas, it may also be used in rural areas where butter is the main dairy product and in areas where beef/live animals are the main production outputs.

2. Field performance of the AI system in Ethiopia

The existing AI system is provided exclusively by the public sector through mobile, stationary and on-call basis (urban areas). One AI technician is expected to inseminate on average about 300 cows per year, and in practice ranges from 50 to 1000. Pregnancy rate to first insemination is 27% in the existing AI system (Desalegn et al. 2009) with huge regional variation (Table 1). Considering that only half of the pregnant cows will deliver female calves, the annual output of an AI technician is about 41 female calves. Weak performance of the AI system has led to the country to having only about 750,000 improved dairy type animals. Problems associated with the existing AI system include technical limitation, lack of transport facility, poor quality of semen, poor heat detection, lack of incentive, and unavailability of the service off-working hours (weekends, holidays, etc.).

Table 1: Conception rate to first AI service in some regions in Ethiopia

Location	No.	Conception rate(%)
Addis Ababa	87	40.2
SNNPR	84	33.3
Oromia	70	34.3
Tigray	70	7.1
Amhara	64	20.3
Total	375	27.1

Source: Dessalegn et al. (2009).

Currently AI is undertaken by one or two AI technicians based at district level. They are mainly providing services for dairy cows in urban and/or peri-urban areas—hence little or no AI services are available for the meat and butter system in rural areas. Cows which are in heat are reported to the AI technicians by the owners. Technicians usually visit the farm to inseminate the cow or in some cases the farmer brings the cow to AI sites or the district offices for insemination. Based on studies/national statistics, on average one AI technician inseminates about 300 cows/annum and pregnancy rate after first insemination is around 27%. Considering that only half of the pregnant cows will deliver female calves, the annual output of an AI technician is estimated at about 41 female calves. Given the shortage of AI technicians and the low output/technician, the impact of AI on the number of genetically improved dairy animals for fluid milk in and around urban areas is limited and genetic improvement of dairy and meat animals in rural areas is almost negligible. The poor field performance of artificial insemination could be associated to a number of factors. Proper understanding of the oestrous cycles, oestrus period and technical efficiency to undertake artificial insemination for effective result are fundamental.

3. The science of oestrus synchronization in Ethiopia

In Ethiopia, studies on hormone assisted oestrus synchronization in cattle started in the late 1980s by a team of researchers in the Animal Health and Reproduction Section of the then International Livestock Centre for Africa (ILCA), now International Livestock Research Institute (ILRI). The research program was initiated with a long-term objective of integrating emerging reproductive technologies, such as embryo transfer and associated techniques, to improve genetics and breeding of indigenous cattle for desirable traits and also to explore opportunities of using these technologies for genetic conservation of indigenous cattle in Africa. This focus of the research program was broadly defined as genetic improvement of cattle for milk and meat production, genetic improvement of trypanotolerant cattle breeds, genetic improvement of cattle for feed utilization efficiency, etc. In addition to using the ILCA research centres in Debre Berhan and Debre Zeit, scientists undertook collaborative work with the Ministry of Agriculture, particularly at the Abernsosa Cattle Improvement and Multiplication Centre and the Gobe Cattle Improvement Centre.

The initial work focused on understanding the oestrus physiology control of oestrus cycle of indigenous zebu and Holstein Friesian x Zebu crossbred cattle. Studies focused on characterization of the oestrus cycle, determination of milk/plasma progesterone profiles during the oestrus cycle of heifers and cows, determination of puberty in heifers, understanding of ovarian functions during the post-partum period, embryonic mortality, luteolytic effects of different hormones (prostaglandins, progesterone releasing intravaginal device (PRID) and progestagin ear implants), dose-response studies, effects of different preparations and does of prostaglandins on pregnancy rates. A number of scientists contributed to the study—A.C. Warnick, University of Florida, and Mukassa-Mugerwa, Tafesse Mesfin, Azage Tegegne, Hizkias Ketema, Yihun Teklu, Sando Sovani, Mario Mattoni, Gino Cecchini, Roberto Francescini, and E. Mutiga.

This work continued and expanded to include embryo transfer and the first calf from embryo transfer was born in 1991 at the then ILCA Debre Zeit Research Station. The study was led by Azage Tegegne and involved two young Italian veterinarians, Roberto Franceschini and Sandro Sovani. The first Borana calf produced was named 'RAS'—representing the first letter of the names of the three scientists (Figure 2). This was followed by production of eight pairs of identical twins using embryo splitting technology. Work continued until the mid-1990s when ILCA and International Laboratory for Research on Animal Diseases (ILRAD) merged in 1994 to form ILRI and a new set of research programs and restructuring affected the work.

Figure 2: The first calf born through embryo transfer, named 'RAS' at ILRI Debre Zeit Research Station.

Among Ethiopian institutions, the National Artificial insemination Centre of Ministry of Agriculture published a paper in Tropical Animal Health and Production in 1996 on the effect of intra-vaginal administration of cloprostenole in Ethiopian highland Zebu (Heinonen et al. 1996). Ten years later, the Faculty of Veterinary Medicine of the Addis Ababa University, took up some studies and the first work on Fogera heifers was published in the Journal Tropical Animal Health and Production by Bekana, M. et al. 2005). Not much happened after that.

4. Why hormonal oestrus synchronization and mass Insemination?—The Ethiopian context

The initial idea of mass hormonal oestrus synchronization was triggered by the following reasons: First one is the shortage and high price of crossbred dairy type animals for smallholder farmers to participate in market-oriented milk production. Second is the unavailability of artificial insemination service (both private and public) in areas where smallholder farmers have the opportunity to participate in milk production and marketing. Third is the slow progress made over a long period of time in genetic improvement of cattle for milk production using the traditional approach of AI in the country. This overall resulted in underdeveloped dairy sector despite the high potential the country has for dairy production. Shortage and high price of improved crossbred dairy type animals also limited smallholder farmers from participation in production and marketing of milk. The application of hormonal oestrus synchronization and mass insemination was visualized with the following context:

- Produce desired germplasm in a short period of time and kick start the dairy system and improve the beef system.
- Enhance smallholders access to improved dairy genetics in areas where there is potential for developing market-oriented dairy production and marketing system.
- Improve AI efficiency—concentrated time, intensive and better heat detection, availability of AI technicians and more precise insemination.
- Match calving season with feed availability—improve milk production, increase calf survival and enhance calf growth.
- Block calving in dairy system and avoid milk production during fasting season.
- Block calving in beef system—uniform animals, easy management, reduce time required for oestrus detection, shorter calving season/tighter breeding season, more uniform weaning weights, ease of management practices (dehorn, castrate, etc.).
- Labour-saving tool for utilizing superior genetics.
- Better management tool for maintaining proper calving interval.
- Facilitate embryo transfer and recipient preparation/synchronization.

5. The first attempt under smallholder farmers' condition

The Improving Productivity and Market Success (IPMS) for Ethiopian smallholders' project designed and implemented the first on-farm hormone induced oestrus synchronization and mass insemination in Alemata district, Tigray region in 2007. Cattle production (for butter and meat) was one of the commodities identified for market-oriented development in Alamata district. Accordingly, Office of Agriculture and Rural Development (OoARD) of Alamata and IPMS organized farmers and formed a dairy marketing cooperative in May 2005. Cooperative members and experts visited Ada'a dairy cooperative in Oromia region in November 2005. The members got very good experience and shared the knowledge they gained from the tour to other farmers in Alamata. Members of the cooperative increased from 20 (the founders) to 135 farmers. Above 85% of the members were female-headed households. As the cooperative members realized the benefits, farmers demanded better yielding animals and started improved feeding and management of their milking animals. Better milk yielding animals (Begait cattle breed) found in western Tigary were identified and 40 heifers were distributed to farmers. Demand for AI service increased to a large extent.

To better respond to the demands of farmers in Alamata, the IPMS project developed an oestrus synchronization program and implemented it in November 2007. The project trained some of the experts in the OoARD and participated in the synchronization program. A total of 54 farmers in Limaat rural kebele, Timuga rural kebele and Alamata town participated in the program. Out of 88 cows presented, 50 were not fit for the program for various reasons, but mainly due to poor body condition. The remaining 38 cows were treated with single injection of PGF2α (Lutalyse and Estrumate; Figure 3) and were inseminated upon observed oestrus. Results were not bad with oestrus response of 76.3% (29/38) and pregnancy rate of 45% (13/29). Out of the 16 non-pregnant cows, 1 was sold, 12 remained non-pregnant and 3 cows were bred naturally by local bulls and became pregnant. Note field activities in Figure 4.

Figure 3: Prostaglandin F2α (Lutalyse and Estrumate) were used to synchronize cows.

Figure 4: The first experience on oestrus synchronization and mass insemination under smallholder farmers condition in Alamata district, Tigray region (November 2007).

Although the oestrus response to hormone treatment and pregnancy rate were encouraging, there were some technical and organizational problems encountered. These included:

- Lack of proper understanding of the concept of oestrus synchronization by woreda experts and farmers.
- Poor communication with farmers by woreda experts in explaining the concept and process involved in oestrus synchronization.
- Selection of unsuitable animals. Poor body condition resulted in rejection of almost 57% of the cows presented.
- Poor preparation to undertake the AI service. Shortage of liquid nitrogen and semen delayed the implementation plan. In fact, the semen used for the synchronization was brought from Dessie town in Amhara region.
- Poor technical capacity and lack of experience by the woreda AI technician. Experienced AI technician had to be borrowed from an adjacent woreda, Korem.
- Transport and fuel shortage limited movement of experts to supervise field activities.
- Weak support from administrative bodies and assignment of woreda experts to other activities after the synchronization work.
- Poor oestrus detection by farmers.
- Exposure of hormone treated cows to local bulls.

Another attempt evolved in the lowlands of Metema district in Amhara region. Based on studies on cattle production and performance in Metema, although there is a good export market for live animals to the Sudan, high cattle population and large holdings and large underutilized feed resource, there is a mismatch between the cattle genotype and the environment. The majority of the cattle population in the district is highland zebu brought with settlers. This has exposed the cattle population to high environmental stress, particularly heat and water and as a result, fertility and calving rate are low, pre-weaning calf mortality is high, milk yield is low and growth rate is slower resulting in low market weight.

Introduction of an indigenous lowland cattle breed for crossbreeding with the local highland zebu was considered as an option and IPMS and Amhara Regional Agricultural Research Institute (ARARI) agreed to test this approach. In 2007, a total of 12 young Borana bulls were purchased from the Adami Tulu Agricultural Research Centre of Oromia Agricultural Research Institute (OARI) and were transported to Bahir Dar and kept at the Andassa Livestock Research Centre of ARARI until they were able to breed (Figure 5). In 2007, these young bulls were transported to Metema and distributed to individual farmers who were willing to test them on their own cows and also provide service to the community. The first Borana crossbred calves were born in 2008 (Figure 6).

Figure 5: Young Boran bulls from Adami Tulu Agricultural Research Centre of OARI at the Andassa Livestock Research Centre of ARARI.

Figure 6: Oestrous synchronization in the field and the first twin Borana crossbred calves born from natural mating in Metema (August 2008).

With this encouraging results and increasing demand from farmers, the natural mating effort was supplemented with oestrus synchronization and mass insemination using Borana semen from National Artificial Insemination Centre (NAIC). After four years, in October 2013, the Metema district Office of agriculture and farmers which owned the Borana crossbred animals organized a field day to demonstrate the adaptability and performance of the crosses produced through hormonal synchronization in the lowland agro-ecology (Figure 7).

Figure 7: A field day organized in Metema district to show performance of Borana crossbreds.

Based on the above experience and observations in the field at Alamata and Metema, it was realized that a combination of technological, organizational and institutional changes needed to be in place to ensure an effective and efficient implementation of the field oestrus synchronization program under smallholder farmers conditions. As a result, a different strategy was designed as follows.

6. Preparations, training and capacity building for field application in Ethiopia

6.1 Technological, organizational and institutional changes

Technologically, the use of hormones is introduced to regulate the heat cycle of a cow. The use of hormones to regulate the heat cycles of zebu and crossbred cows is known by scientist who conducted research on this technology in the late 1980s and early 1990s. Some of the most common uses for the hormones in the Ethiopian context were to match calving rates with feed availability and avoidance of high milk production during the fasting period. Another use was to control heat period and allow more accurate AI service.

Organizationally, the use of a highly qualified mobile team is introduced instead of the stationary AI technicians and livestock staff in one location. Each mobile team should comprise two highly trained AI technicians and two extension specialists with livestock expertise, veterinarian and one livestock researcher. Since, presently, no AI staff is employed at regional and zonal level, staff should be recruited from districts and assigned by the regional or zonal office of agriculture or the research institution.

Institutionally, the major change is the insemination of several cows at the same time in one location instead of the traditional approach of inseminating individual cows in different locations. The technological intervention linked to this institutional change is the hormonal synchronization of the heat cycle of the cows to be inseminated.

In support of this institutional change the extension staff has to create awareness, understanding and interest on the purpose of the mass insemination in selected districts (with the help of the AI technicians). Once this has been accomplished, farmers are informed about the type of animals to be selected for mass insemination, using technical criteria, amongst other body condition score. Participating men and women farmers were also trained on the subject, oestrus detection and management of dairy cows. Appropriate dates for mass treatment with hormones and subsequent insemination are set as well as a location for the insemination. Appropriate animal handling facilities for the mass insemination have to be constructed in case they are not available. All logistical arrangements for the hormone treatment and insemination have to be spelled out, including the responsibilities of the different partners, other than the mobile teams. Veterinarians and AI technicians carry out the hormone treatment and inseminations on the pre-determined dates, including all the diagnostic work on the animals. For action research purposes, records for all cows offered for hormonal treatment and AI are kept by the livestock researcher; ear tags should be used to mark all 'treated' cows. Also, for action research purposes, pregnancy test should be carried out two to three months after insemination.

6.2 Establishment and capacity building of regional teams

In 2010, multi-disciplinary regional teams composed of animal production experts, breeders, feeds and nutrition experts, veterinarians, and AI technicians were assembled and trained on reproductive physiology and hormonal synchronization techniques at the Ethiopian Meat and Dairy Technology Institute (EMDTI) at Debre Zeit (Figure 8). The names and roles of these trainees is presented in Table 1.

Figure 8: The first group of trainees from Tigray and SNNPR at the EMDTI in Debre Zeit.

Table 2: The first participants from Tigray and SNNP regions on a training program on hormonal oestrous synchronization at EMDTI, Debre Zeit, 4–9 October 2010

No.	Name	Sex	Organization	Location
Tigray				
1	Woldeyesus G/Yohanes	M	Tigray Agricultural Research Institute (TARI), Livestock Production	Mekelle
2	Abraham Haftu	M	TARI, Livestock Production	Mekelle
3	Amdemichael Adhanom	M	TARI, Veterinarian	Mekelle
4	Tesfay G/Mariam	M	OoARD, Veterinarian	Adigrat
5	Medhanye Tekle	M	OoARD, Veterinarian	Wukro
6	Alem G/Mariam	M	OoARD, AI Technician	Adigrat
7	Gebrehiwot Hagos	M	OoARD, AI Technician	Wukro
SNNPR				
1	Tesema Godana	M	Office of Agriculture (OoA), AI Technician	Dale
2	Kefyalew Megene	M	SNNRP Agricultural Research Institute (SARI), Veterinarian	Awassa
3	Debir Legesse	F	SARI, Livestock Production	Awassa
4	Sintayehu Tesfu	M	OoA, Veterinarian	Dale
5	Gizachew Bayleyegn	M	SARI, , Veterinarian	Awassa
EMDTI				
1	Olga Karenfil	F	EMDTI, Veterinarian	Debre Zeit
2	Redeat Belayneh	F	EMDTI, Veterinarian	Debre Zeit

7. The first extensive field application under smallholder production system

7.1 First field test in Tigray and SNNP regional states

The first extensive field application under smallholder production system using trained regional teams was conducted in Adigrat-Mekelle milkshed in Tigray Regional State, in the north and the Awassa-Dale milkshed, southern region in the south (Figure 9). These two milksheds were purposively selected due to a large market potential in the regional capitals. Households with at least two cows (heifers), who have adequate feed resource, with experience in managing dairy animals and milk marketing were selected. Cows with body condition score of 4 and above (scale 1-9), in good reproductive health and with functional corpus lutea on rectal palpation were selected and used (Figures 10 and 11). Oestrus was synchronized using single injection of prostaglandin F2α. Cows that showed oestrus within 24 hours were inseminated, while the remaining cows were brought to a central animal handling facility and checked for oestrus and inseminated over a period of five days.

Figure 9: Locations of the Adigrat-Mekelle and Awassa-Dale milksheds in Ethiopia.

Figure 10: The first round of synchronization in Adigrat-Mekelle milkshed, Tigray region, January 2011.

Figure 11: The first round of synchronization at Bera Tedicho rural Kebele in Dale district, Sidama sone, SNNPR—August–Jan 2011.

7.2 Results

Awareness creation and community mobilization and infrastructure development

Regional teams identified study locations and participating farmers in the project. Public awareness meetings were held and community mobilization efforts undertaken. Both the government and the communities contributed resources for the construction of proper animal handling facilities at strategically selected sites. The IPMS project provided technical assistance in the form of capacity building and supplied hormones and other field consumables. Regional governments provided semen, AI consumables, local transport and other logistic support.

Technological, organizational and institutional innovations

Technologically, the use of hormones is introduced to regulate the heat cycle of a cow (Figure 12). The use of hormones to regulate the heat cycles of animals is well established. Organizationally, the use of highly qualified mobile teams was introduced instead of the stationary AI technicians in one location. Each mobile team comprised highly trained three AI technicians, extension specialist, livestock expert, veterinarian and livestock researcher. Institutionally, the major change was the insemination of several cows at the same time in one location instead of the traditional approach of inseminating individual cows in different locations. The technological intervention linked to this institutional change is the hormonal synchronization of the heat cycle of the cows.

This mass AI intervention aims at improving the effectiveness of the insemination (increasing pregnancy rate/first insemination) and the efficiency of the AI service delivery (more inseminations/AI technician). Initial results indicate that pregnancy rate after first insemination can be improved from 27 to 62%, mainly as a result of timely availability of well-trained AI technicians at the time of planned heat period. Efficiency results of mass insemination in two milksheds indicate that respectively 200 and 175 animals were treated with hormones/inseminated over a two week period by two AI technicians per milkshed. This results in about 45 inseminations/AI technician per week—as compared to six insemination/AI technician per week in the existing system. A new round of action research on mass insemination has taken place in the past months with 1400 animals based on i) An assessment of the initial results and lessons learned by the stakeholders (workshop) and ii) New knowledge and technology including the use of sex fixer to increase the probability of birth of female calves. Regional governments are developing plans to scale out this new AI approach for both dairy and beef production.

Further improvement in the AI system's effectiveness and efficiency can be tested including i) Use of selected semen (local as well as exotic) of different breed for the butter, milk and meat system ii) Use of sexed semen or sex fixer to increase the proportion of female calves born in the dairy system and iii) Testing different organizational and institutional models for mass insemination including commercial mobile AI teams.

Figure 12: Clear mucus after oestrus synchronization.

Table 3: Performance of oestrus synchronized cows in two regional states, Ethiopia

Variables	Awassa-Dale milkshed		Adigrat-Mekelle milkshed	
	No.	%	No.	%
Total animals presented for synchronization	210	-	212	-
No. animals treated with $PGF_{2\alpha}$	175	83.3	199	93.9
No. of cows that aborted after treatment	-	-	6	3.0
Final no. of cows synchronized	175	100	193	97.0
No. of animals that responded to $PGF_{2\alpha}$ treatment	171	97.7	193	100.0
Animals that died (after insemination)	3	1.8	-	-
Animas that did show up for pregnancy diagnosis	5	2.9	-	-
Interval to oestrus, hours	NA	-	45.13	-
Pregnant animals	94	57.7	119	61.7

Based on the above encouraging results, a field day was organized to inspect the first batch of calf crop in Tigray Region in the presence of the Regional President, Abay Woldu and other senior officials (Figure 13).

Figure 13: Tigray Regional President, Abay Woldu inspecting the first batch of calf crop at Wukro produced through hormonal synchronization.

Further engagement with regional authorities continued. In the SNNPR, the Regional President, Shiferaw Shigute, requested for a briefing about the technology and the potential for improving availability of dairy type of animals to smallholders in the region (Figure 14).

Figure 14: SNNPR President, Shiferaw Shigute and senior regional officials attentively listening to a presentation on experiences of oestrus synchronization in Ethiopia in his office in Hawassa.

7.3 Consolidating Tigray and SNNPR results

In September 2011, second phase consolidation continued in the Mekelle milkshed and Axum milkshed. In the Mekelle milkshed, Adigrat, Wukro and peri-urban areas of Mekelle city were included and in Axum milkshed Axum, Adwa and Dura areas were included. A total of 500 cows were synchronized and bred in these two milksheds (Figure 15).

Figure 15: Expanding oestrous synchronization and mass insemination into Axum area, Central Zone, Tigray region (September 2011).

The second phase synchronization work continued and expanded into Bensa, Aleta Wondo, and Arbegona districts in SNNPR.

7.4 Expanding to Amhara and Oromia states

In Amhara Region, the training was organized in October 2011 at the Andassa Livestock Research Centre and about 30 experts from ARARI and Bureau of Agriculture (BoA) participated (Figure 16). In Oromia, Ada'a district in East Shoa and Ambo area in West Shoa were selected for the first round of synchronization in February 2012 (Figure 17).

Figure 16: Field activities were undertaken in Dangella, Koga and Andassa areas, Amhara region.

Figure 17: Synchronization work in Ada'a district, East Shoa Zone (left) and Amaro PA in Ambo area, West Shoa Zone, Oromia region; some cows were already in heat upon presentation for synchronization.

8. Scaling out phase

8.1 Preparation—National workshop organized by Ministry of Agriculture (MoA) and LIVES

The IPMS/LIVES project in collaboration with the Federal MoA organized a national workshop on '*Alternatives for improving field AI delivery system to enhance beef and dairy production in Ethiopia*' from 18–19 July 2011 at the ILRI, Addis Ababa campus.

The objective of the workshop was to share experiences on technologies, methods, approaches, and processes the project has tested in partnership with Regional BoA and research institutions and to harmonize research and development programs on alternatives for improving field AI delivery system to enhance beef and dairy production in Ethiopia' among the four regional states.

Since 2005, the IPMS Project working with partners facilitated numerous interventions in participatory market-oriented development. In the past two years, the IPMS project with its partners gained experience with mass insemination of cows in two of its pilot learning woredas (PLW), Alamata and Metama)—and more recently in another two milksheds, one in Tigray and another in SNNPR. Since results are promising, the IPMS project will assist the national and regional research and development partners in developing programs aimed at a more effective and efficient AI service delivery system. Ultimately, such activities are expected to feed into the new ILRI/International Water Management Institute (IWMI) and LIVES project.

There is now a significant volume of lessons and experiences that will be of relevance to the wider research and development community. These lessons and experiences may also be of importance and timely for the scaling out and scaling up envisaged in the Growth and Transformation Plan. In order to determine the project support, a clear distinction was made between testing the system (adaptive research phase) and scaling out the system for widespread adoption (development adoption phase).

During the workshop, a model mobile animal handling facility designed by LIVES project was demonstrated to regional experts and other participants of the workshop (Figure 18). Each region was provided with one model animal handling facility to help and facilitate the scaling up effort. List of participants of the workshop is available in Annex I.

Figure 18: Demonstration of a mobile animal handling facility for scaling up of oestrus synchronization activities.

The workshop participants (see list of participants in Annex I) were provided with a list of technical and organizational issues to be considered during the field operation of the synchronization program.

8.2 Scaling out by Federal MoA, Regional BoA and RARIs

Tigray

Based on the initial results in 2011, the BoA in Tigray moved to scaling up the technology to strategically selected milksheds and synchronized and inseminated 16,145 cows in 2012.

SNNPR

In the SNNPR, SARI and the BoA jointly scaled up this activity. The following was posted on SARI website '*A strong effort has been exerted to address one of the neglected but a highly important component of agriculture, the livestock sector, particularly targeting improved cattle milk production. In collaboration with the ILRI/IPMS project, SARI has tested the use of hormone to synchronize estrus and increase efficiency of artificial insemination under smallholder farms. Following a successful demonstration of the technology in five woredas in 2010/2011, the institute initiated a large-scale mass synchronization and insemination program region wide in 2011/2012 targeting 54 woredas and about 24,000 cows. The program was carried out in collaboration with the BoA with huge financial support from the regional government. In the first 2 months of its inception alone, the technology was successfully disseminated to more than 50 woredas and addressed about 15,000 cows*.

Amhara

Hormone assisted oestrus synchronization and mass artificial insemination of cows was introduced to Amhara region in October 2011 when a number of experts were trained and field activity was implemented in selected areas around Koga dam, Dangela and Andassa area. Based on the results obtained in these locations, farmers and experts in Mecha district showed interest on the new technology and a program was organized by the Regional Livestock Development and Promotion Agency, ARARI and LIVES project. More than 1000 cows were presented by local farmers to the synchronization site and a team of AI technicians checked and synchronized 934 cows on the first day alone (Figure 19). Now, the farmer's interest in this technology regardless of gender and age was observed to be incredible. In the meantime, the Amhara region livestock development and promotion agency is scaling out this oestrus synchronization technology.

Figure 19: Oestrus synchronization campaign at Mecha district, Amhara region (November2013); note a modified animal handling facility to inseminate five cows in one go.

Oromia

In Oromia, after the first round of synchronization in Ada'a district, East Shoa zone and Ambo area in West Shoa, in February 2012, the Regional Livestock Development and Health Agency scaled out the activity the same year and synchronized 37,500 cows in 42 zones with selected milksheds. They organized a regional team, zonal team and district teams to implement the program.

Although the regions started scaling up the technology in different years, data on the number of cows synchronized from the experimental phase up until 2014/15 are presented in Table 3. From 2010/11 up to 2014/15, the plan was to synchronize and inseminate a total of 769,673 cows and about 611,203 (79.4%) cows were synchronized and inseminated. Regional achievements varied from 71 to 97% of the planned activities.

Table 4: Number of cows treated with hormone and inseminated in the four regional states from 2011 to 2014

Region	2010/11	2011/12	2012/13	2013/14	2014/15	Total
Amhara						
Planned	0	318	534	641	69,825	71,318
Inseminated	0	318	479	515	67,895	69,207 (97.1%)
Oromia						
Planned	0	0	45,000	50,496	306,000	401,496
Inseminated	0	0	43,861	45,837	193,533	283,231 (70.6%)
SNNPR						
Planned	210	22,264	39,042	31,545	53,083	146,144
Inseminated	175	20,373	32,578	28,232	48,187	129,545 (88.7%)
Tigray						
Planned	13,190	17,031	36,781	37,461	46,252	150,715
Inseminated	11,211	13,624	31,864	33,081	39,440	129,220 (85.7%)
Total						
Planned	13,400	39,613	121,357	120,143	475,160	769,673
Inseminated	11,386	34,315	108,782	107,665	349,055	611,203 (79.4%)

Source: Regional Bureaus of Agriculture (2015). Numbers in brackets are percentage achievements.

The way forward: Growth and Transformation Plan (GTP) II (2015/16–2019/20)

The Ethiopian GTP II was developed based on the livestock master plan (LMP) of the Ministry of Agriculture. With regard to dairy development, the cow dairy development roadmap (2015/16–2019/20) has also been developed.

Cow dairy development roadmap

Vision

By increasing the number and productivity of cattle through improvements in genetics, health and feeding, domestic cow milk production will increase by about 93% by 2020, consumption demand will be satisfied, and export of cow milk and milk products will start.

Overall target

Raise total cattle milk production to 7967 million litres by 2020 through genetics, feed and health interventions to transform traditional family cow dairy to improved family dairy (IFD) and expand and improve specialized dairy production (SP dairy) units.

Targets

AI and synchronization intervention combined with feed and health interventions is recommended to be carried out in mixed rainfall sufficient (MRS) typology zone, where AI and synchronization is profitable according to the livestock sector analysis (LSA) results.

The specific targets include:

The number of households participating in the intervention activity will reach 1.3 million by 2020. The expected increase in number of crossbred cattle in IFD systems in the MRS zone during GTP II will be over four million or almost eight times the base year number. In IFD, with the adoption of the intervention during GTP II crossbred dairy cattle will:

- Produce an average of 6 litres of milk per day vs 1.9 litres/day for local cattle milk (an increase of 216%).
- Weigh 375 kg while the average live-weight of adult local animals is 280 kg.
- Have a lactation length of 270 days on average vs 200 days for local breeds (an increase of 35%).
- Give average milk production per year of 1053 vs milk production of 247 litres/year for local breeds (a 326% increase).

Crossbreeding through AI and synchronization in MRS typology zone

Synchronization and AI intervention combined with feed and health interventions is targeted at the MRS typology zone where it was found to be profitable and shows high internal rate of return (IRR) values (for small IFD IRR = 32.5% and for medium IFD IRR = 23.7%). In contrast, the AI and synchronization intervention in mixed rainfall deficient (MRD) typology zone is not profitable as it shows very low IRR values (IRR = 1 for small MRD and IRR = 5 for medium MRD). Similarly, crossbreeding is not recommended for lowland grazing (LG) pastoral and agro-pastoral systems due to shortage of feed and high temperatures in the LG typology zone.

The AI and synchronization intervention:

- Adoption of AI and synchronization will reach 32% of the reproductive female cattle in MRS by 2020 starting with 10% in the first year (2015/16).
- At least 20,000 public and private AI technicians, including farmer AI technicians, will be trained during the five-year GTP II activity.
- The number of households participating in the intervention activity will reach 1.3 million by 2020.
- At least the 1.3 million adopting farmers will be trained on better husbandry and feeding practices of rearing crossbred dairy cattle and handling of dairy production.

For the five year GTP II period a total investment of ETB 146 million is needed to improve the capacity of the AI centres and the AI service, and the training of AI technicians. It is assumed that farmers will cover the costs related to each AI and synchronization service provided. The cost of synchronizing is estimated at ETB 100 per synchronization and the AI service is estimated at ETB 120 per service. Assuming a double insemination, the cost of the farmer per service is estimated at ETB 340. At national level the total recurrent cost for AI and synchronization service covered by the farmer is ETB 2817 million. The investment of the government of Ethiopia (GOE) to put in place the AI and synchronization services for the intervention is only ETB 148 million.

The contribution to national milk production from IFD increases from 167 million litres in 2014/15 to 1490 million litres by 2020, an increase of 793%. The GDP contribution of IFD system increases from ETB 1.1 billion in 2014/15 to ETB 10.0 billion in 2020, an increase of 793%.

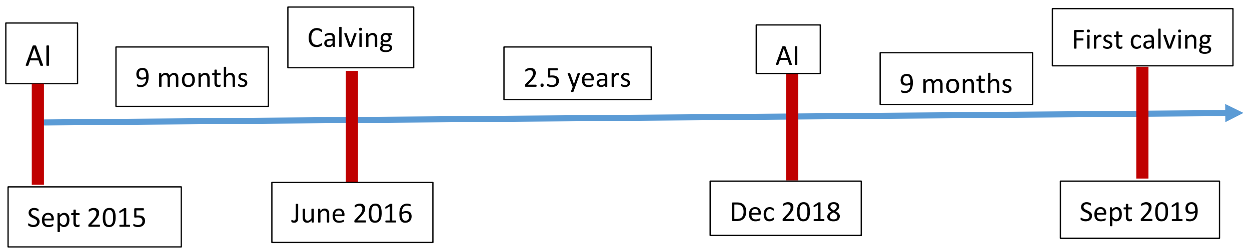
These combined interventions would result in a 93% increase national cattle milk production over the GTP II period (from 4132 in 2015 to 7967 litres in 2020). Increase on the contribution of cow milk to the national GDP from ETB 28 billion in 2014/15 to ETB 52.9 billion in 2019/20. Production of a surplus of 2501 million litres of cow milk over projected domestic consumption requirements by 2020. This surplus could substitute for imported milk products and could be used domestically for new or additional industrial uses (e.g. in the baking industry) or be exported as milk powder or ultra heat treated (UHT) to raise foreign exchange earnings.

In summary, the plan is to increase crossbred dairy animals from 750,000 in 2014 to about 5 million in five years (2014/15 to 2019/20). This will result in a 93% increase in milk production in five years (4132 million in 2015 to 7967 million litres in 2020). This will increase the contribution of cow milk to GDP from ETB 28 to 52.9 billion. There will also be a surplus of 2501 million litres over projected domestic consumption requirements by 2020, which could be used as an import substitute or could be used domestically or be exported as milk powder or UHT to raise foreign exchange earnings.

When will the milk from the crossbreds be available?

Assuming the first round of synchronization and mass insemination of local cows starts in September 2015, the crossbred calves will be delivered in June 2016. Given good feeding and management of these calf crop, we hope that they will be ready for first insemination at an average age of 2.5 years, which will be around December 2018. These heifers will deliver their first calves in September 2019, when they start their first lactation. Although there will be increase in milk output from the local cows over time, the first drop of milk from a crossbred heifer impregnated in September 2015 will be available in September 2019 due to biological phenomenon and limitation (Figure 20). This means that the huge impact of this effort on total milk production will be demonstrated beyond 2019 as there will be more cows calving and lactating after this time.

Figure 20: The time required to produce the first calf crop of crossbred (F1) heifers until they start the first lactation.



How many local cows should we crossbreed per year to attain the GTP II goal of five million crossbred females?

Table 5: Minimum number of cows to be synchronized and inseminated per year in order to achieve the GTP II goal

	Number
No. of local cows selected, synchronized and inseminated per year	5,000,000
Expected calving rate (50%)	2,500,000
Expected sex ratio (50% female)	1,250,000
Estimated calf and young mortality (15%)	187,500
Available no. of heifers per year	1,062,500
Available no. of heifers over five years	5,312,500

Note: Similar number of male animals will be available for beef production.

The focus during GTP II should therefore be in accelerating and improving efficiency and efficacy of synchronization and AI to ensure the minimum number of crossbred calves are produced as stipulated in the plan. In order to attain the goal of producing five million crossbred heifers over the five year period, about five million cows have to be selected, synchronized and inseminated per year. This will result in the production of about 1.06 million heifer calves per year as shown in Table 4. Since the number of crossbred animals produced per year will be around 1.06 million, minimizing pre-weaning calf mortality, nutrition and management of the young animals is essential. Regarding milk production and marketing, however the focus should be on the animals produced during GTP I.

Where are the calves produced during GTP I?

The scaling up exercise of this activity started in different years across the regions. However, most regions started the activity in 2012/13, the first calves born are already about two years old and will be ready for breeding if they are managed properly. Therefore, the majority of these animals will start calving for the first time in 2015/16. Although data on pregnancy and calving are not yet available, based on the experiences of the regions, a rough and conservative estimate of performance in terms of female calf production is made based on calving rate of 40% and mortality rate of 15% as shown in the Table 5.

Table 6: Estimated number of calves produced through synchronization and insemination during GTP I (based on regional reports presented in Table 3).

	Amhara	Oromia	SNNP	Tigray	Total
No. inseminated	69,207	283,231	129,545	129,220	611,203
Calving (40%)	27,682	113,292	51,818	51,688	244,480
Mortality (15%)	4153	16,994	7773	7753	36,673
Available calves	23,530	96,298	44,045	43,935	207,808
Male calves	11,765	48,149	22,023	21,967	103,904
Female calves	11,765	48,149	22,023	21,967	103,904

We assume that about 103,904 heifer calves are available from the work undertaken by the regions during the scaling out exercise in GTP I. Assuming a 10 litres/day production over a lactation period of 300 days, these cows would produce 374,054,400 litres of milk per year. At a farm gate milk price of ETB 10/litre, this will translate in to ETB 3,740,544,000/annum. For this to happen, however proper feeding, management and health care are required. Milk marketing also becomes a critical issue and needs to be addressed to ensure sustainable development of the dairy sector. In addition, since most of the heifers produced during the GTP I period are F1 crosses, a proper plan has to be developed to follow up on the subsequent genetics and re-breeding of these animals in the coming years.

What preparations are required for implementing GTP II?

The Ministry of Agriculture plans to implement this genetic improvement program in strategically selected 13 milksheds. Depending on the level of development of the dairy value in these milksheds, the number of animals to be crossbred could vary. However, we can roughly estimate this to be on average about 384,616 cows/milkshed per year.

If the plan is to synchronize and inseminate five million cows per year, this will require availing to five million doses of hormone per year, totaling 25 million doses over the period of GTP II. Assuming an average of 90% oestrus response to hormone treatment, a total of 4.5 million straws of good quality semen will be required, again totaling 22.5 million straws over the GTP II period. In order to avoid potential in-breeding the number of bulls and their genetic relationship is another factor to consider from the outset.

Preparations have to be made to ensure adequate production and supply of liquid nitrogen is in place. Other equipment and supplies have to be purchased ahead of time for a smooth operation of the program. Transport facilities and other associated costs such as such as construction of animal handling facilities, and logistic support have to be properly planned and implemented if the goal set by the plan is to be realized.

How may AI technicians do we need to achieve the goal?

As shown in Table 4, in order to achieve the GTP II goal, the minimum number of cows to be synchronized and inseminated per year is about five million. If we have a total of 2,000 good AI technicians in the country and are provided with all the equipment, supplies, support and incentive, each will have to inseminate 2500 cows per year to achieve the national annual target. If the breeding season is defined to be a period of 90 days (when the body condition of cows is at optimum), then each AI technician will have to synchronize and inseminate of 30 cows per day over the three months breeding season (this could be adjusted based on availability of animals and other facilities and supplies). This will result in insemination of 2700 cows per AI technician. At a national scale, this will add up to insemination of 5.4 million cows per year, surpassing the minimum number of cows required to achieve the GTP II plan. From our experience, an AI technician with a team could comfortably handle 50 cows per day. This could either increase the total number of cows synchronized and inseminated to nine million or reduce the number of days of engagement during the breeding season to about 55 days. For effective implementation of this plan, a rigorous and continuous training program has to be in place to enhance the efficiency and effectiveness of these AI technicians.

What do we do with the male calves?

As shown in the above table, a total of 5,312,500 male calves will be born over the five year plan period. This is a huge resource and a clear plan and management system has to be developed to ensure that they contribute to the beef sector.

Synchronization ≠ dairy value chain development

Since this is an issue of dairy value chain development, genetic improvement is not the only issue to be addressed. In fact, if the environment is not improved to respond to the concurrent improvement in genetics, the result could be more disastrous. Therefore, we have to be ahead of the game and the following issues need special attention:

- How much feed is required to drive the system? Roughages, concentrates, mineral supplements?
- Water—How many litres of water is required a) to produce feed, b) for drinking and c) cleaning, washing, etc.
- Health—Vaccination, drugs, reduction of calf and young mortality.
- Service provision—Advisory services, AI services, Veterinary services?
- Milk hygiene—Handling, marketing and processing.
- Animal identification and record keeping.
- Milk quality—who is responsible?
- Governance issue—Development, promotion and regulation of the sector?

9. References

Awel, H., Eshetu, L., Tadesse, G., Birhanu, A. and Khar, S.K. 2009. Estrus synchronization in sheep with synthetic progestagens. *Trop Anim. Health Prod.* 41:1521 – 1524

Ayalew, M., Tegegne, A. and Hegde, B.P. 2008. Reproductive performance of dairy cows in Yerer watershed. Oromiya Region, Ethiopia. In: the *16th Annual Conference of the Ethiopian Society of Animal Production (ESAP), 8–9 October 2008*, held at the Head Quarters of the Ethiopian Institute of Agricultural Research (EIAR), pp. 219-230. , Addis Ababa, Ethiopia.

Bekana, M., Gizachew, A. and Regassa F. 2005. Reproductive performance of Fogera heifers treated with Prostaglandin F2alfa for synchronization of estrus. *Tropical Animal Health and Production*. 37: 373-379. Short communication.

Ebro, A. and Tegegne, A. 1998. Fertility of *Bos indicus* and *Bos indicus x Bos taurus* crossbred heifers and cows after oestrus synchronization. *Proceedings of the 6th National Conference of the Ethiopian Society of Animal Production (ESAP), 14–15 May 1998*, pp 123-129. Addis Ababa, Ethiopia.

G/Medhin, G., Bekana, M., Tegegne, A. and Blihu, K. 2009. Status of artificial insemination service in Ethiopia. *A paper presented at the 17th Annual Conference of the Ethiopian Society of Animal Production (ESAP), 24–26 September 2009*, held at the Head Quarters of the Ethiopian Institute of Agricultural Research (EIAR), pp.87-104. Addis Ababa, Ethiopia.

Gebreyohannes, G, Tegegne, A., Diedhiou, M.L. and Hegde, B.P. 2002. Reproductive efficiency of zebu and crossbred cows as measured by the inter-estrus and inter-service intervals at Bako. *Proceedings of the 10th Annual Conference of the Ethiopian Society of Animal Production (ESAP), August 2002*, pp. 109-116. Addis Ababa, Ethiopia.

Gebreyohannes, G., Tegegne, A., Diedhiou, M.L. and Hegde, B.P. 2002. Body weight dynamics of zebu and crossbred cows in relation to postpartum reproduction under sub-humid climate of Bako. *Proceedings of the 10th Annual Conference of the Ethiopian Society of Animal Production (ESAP), August 2002*, pp. 131-136. Addis Ababa, Ethiopia.

Kassa, T. and Tegegne, A. 1993. Reproductive performance of indigenous zebu and Friesian x Zebu crossbred cows under smallholder management conditions in Ethiopia. In: *Improving the Productivity of Indigenous African Livestock*. Co-ordinated Research Program organized by the joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture, 21–25 Sept. 1992, Accra, Ghana, pp. 113-119. IAEA, Vienna.

Kassa, T., Tegegne, A. and Shenkoru, T. 1993. Factors affecting postpartum reproductive performance of cows under smallholder management in Ethiopia. *Proceedings of the first Biennial Workshop of the Cattle Research Network (CARNET), 17–21 May 1993*, International Livestock Centre for Africa (ILCA), Addis Ababa, Ethiopia (abstract).

Kassa, T. and Tegegne, A. 1999. Factors affecting reproductive performance of zebu and crossbred cows under small-scale dairy farms. *Tropical Agriculture* 75(4): 468-472.

Mekasha, Y., Tegegne, A., Yami, A. and Umunna, N.N. 1999. Characterization of postpartum reproductive activities using milk progesterone profiles in dairy cows in urban and peri-urban dairy production systems. *Proceedings of the 7th National Conference of the Ethiopian Society of Animal Production (ESAP), 14–15 May 1999*, pp. 307-319. , Addis Ababa, Ethiopia

Mekasha, Y., Tegegne, A., Yami, A. and Umunna, N.N. 2000. Reproductive management and reproductive performance of dairy herds in the urban and peri-urban dairy production systems in the Addis Ababa milk shed. *Proceedings of the 8th Annual Conference of the Ethiopian Society of Animal Production (ESAP), April 2000*, pp. 312-319. Addis Ababa, Ethiopia.

Mekuriaw, Z., Assefa, H., Tegegne, A. and Muluneh, D. 2016. Oestrus response and fertility of Menz and crossbred ewes to prostaglandin based synchronization protocol. *Tropical Animal Health and Production* 48:53–57. DOI 10.1007/s11250-015-0919-z.

Mukasa Mugerwa, E. Tegegne, A. and Warnick, A.C. 1989. Time of artificial insemination and pregnancy rates in Boran (*Bos indicus*) cattle. *Tropical Agriculture (Trinidad)* 66:230 232.

Mukasa Mugerwa, E. and Tegegne, A. 1989. Peripheral plasma progesterone concentration in Zebu (*Bos indicus*) cows during pregnancy. *Reproduction, Nutrition and Development* 29:303 308.

Mukasa Mugerwa, E. Tegegne, A. Mattoni, M. and Cecchini, G. 1989. Effect of oestrous synchronization with prostaglandin F2α in Ethiopian highland Zebu (*Bos indicus*) cows. *Animal Production* 48:367 373.

Mukasa-Mugerwa, E., Tegegne, A. and Teklu, Y. 1991. Characterization of service intervals and frequency of short oestrus cycles in zebu (*Bos indicus*) cows in Ethiopia. Reproduction, *Nutrition and Development* 31:361-367.

Mukasa-Mugerwa, E., Anindo, D., Lahlou-Kassi, A., Umunna, N.N. and Tegegne, A. 1997. Effect of body condition and energy utilization on the length of post-partum an oestrus in PRID-treated and untreated post-partum *Bos indicus* (Zebu) cattle. *Animal Science* 65:17-24.

Mukasa-Mugerwa, E. and Tegegne, A. 1991. Reproductive performance in Ethiopian Zebu (*Bos indicus*) cattle: constraints and impact on production. *Proceedings of the 4th National Livestock Improvement Conference, 13-15 November 1991*, IAR Proceedings No. 4, pp. 16-28. Addis Ababa, Ethiopia.

Mutiga, E.R., Mukasa-Mugerwa, E. and Tegegne, A. 1993. Luteolytic effect of prostaglandin F2α in Boran and Boran x Friesian cross-bred heifers. *Journal of Agricultural Science (Cambridge)* 120:103-106.

Mutiga, E.R., Mukasa-Mugerwa, E. and Tegegne, A. 1993. Superovulation of Boran (*Bos indicus*) and Boran x Friesian cows. *The Kenya Veterinarian* 17:5-8.

Mutiga, E.R. and Mukasa-Mugerwa, E. 1992. Effect of the method of estrus synchronization and PMSG dosage on estrus and twinning in Ethiopian Menz sheep. *Theriogenology* 38:727-734.

Tadesse, M., Thiengtham, J., Pinyopummin, A., Prasanpanich, S. and Tegegne, A. 2011. Estrus performance of Boran and Boran x Holstein Friesian Crossbred Cattle Synchronized with a protocol based on Estradiol Benzoate or Gonadotrophin Releasing Hormone. *Kasetsart University Natural Science Journal* 45:221-232.

Tadesse, M., Tegegne, A., Melesse, A., Degefa, T., Yohanis, A. and Pinyopummin, A. 2012. Reproductive Characteristics of Holstein Friesian Dairy Breed after Estrous Synchronization with Select-Synch with or without CIDR. *Ethiopian Journal of Agricultural Sciences (EJAS)* 22:1-13.

Tadesse, M., Thiengtham, J., Pinyopummin, A., Prasanpanich, S. and Tegegne, A. 2011. The use of vaginal electrical resistance to diagnosis estrus and early pregnancy and its relation with size of dominant follicle in dairy cattle. *Kasetsart University Natural Science Journal* 45:435-443.

Tegegne, A., Entwistle, K.W. and Mukasa-Mugerwa, E. 1993. Plasma progesterone and blood metabolite profiles in postpartum small East African zebu *(Bos indicus*) cows. *Tropical Animal Health and Production* 25:101-110.

Tegegne, A., Estifanos, A., Tera, A. and Hoekstra, D. 2012. T*echnological options and approaches to improve smallholder access to desirable animal genetic material for dairy development: IPMS Experience with hormonal oestrus synchronization and mass insemination in Ethiopia*. Tropentag 2012, Gottengen, Germany.

Tegegne, A. and Franceschini, R. 1993. Evaluation of luteolysis and oestrous synchronization using a prostaglandin analog (Prosolvin) in Boran x Friesian crossbred heifers. *Journal of Applied Animal Research* 4:107-114.

Tegegne, A., Franceschini, R. and Sovani, S. 1994. Superovulatory response, embryo quality and progesterone secretions in Boran (Bos indicus) cows after treatment with either Pluset or Pergovet. *Theriogenology* 41:1653-1662.

Tegegne, A., Geleto, A. and Kassa, T. 1993. Short luteal phases and ovulations without oestrus in primiparous Borana (*Bos indicus*) cows in the central highlands of Ethiopia. *Animal Reproduction Science* 31:21-31.

Tegegne, T., Ketema, H. and Mukasa-Mugerwa, E. 1999. Relationships between dietary supplementation, blood metabolite concentrations and fertility in Boran and Boran x Friesian heifers. *Proceedings of the 7th National Conference of the Ethiopian Society of Animal Production (ESAP), May 14-15, 1999*, pp. 364-375. Addis Ababa, Ethiopia.

Tegegne, A., Khalili, H., Mukasa-Mugerwa, E. and Lahlou-Kassi, A. 1995. Effects of plane of nutrition and age at start of nutritional treatment on body growth, onset of puberty, corpora lutea function and fertility in Boran x Friesian heifers. *Annales des Zootechnie* 44(Suppl. 1):325.

Tegegne, A., Lahlou-Kassi, A. and Mukasa-Mugerwa, E. 1995. Biotechnology in Animal Production. *Proceedings of the 2nd National Conference of the Ethiopian Society of Animal Production (ESAP), 26–27 May 1993*. pp. 49-80. Addis Ababa, Ethiopia,

Tegegne, A., Lahlou-Kassi, A. and Mukasa-Mugerwa, E. 1997. The effect of season on superovulatory response, embryo yield and quality in Boran and Boran x Friesian crossbred cows. *Theriogenology* 47(1):180.

Tegegne, A., Mukasa-Mugerwa, E., Franceschini, R. and Sovani, S. 1994. Nutritional influence on corpora lutea function and fertility in Boran (*Bos indicus*) heifers bred at first oestrus or after three oestrous cycles. In: *Advances in Tropical Agriculture in the 20th Century and Prospects for the 21st*: *TA 2000*. 4–9 September 1994. Trinidad and Tobago.

Tegegne, A., Warnick, A.C., Mukasa Mugerwa, E. and Ketema, H. 1989. Fertility of *Bos indicus* and *Bos indicus x Bos taurus* crossbred cattle after oestrus synchronization. *Theriogenology* 31:361 370.

Tegegne, A., Wirtu, G., Mukasa-Mugerwa, E. and Kassa, T. 1994. Oestrus phenomenon and oestrus detection efficiency using androgenized cows and entire bulls in Boran and Boran x Friesian crossbred cows. In: *Advances in Tropical Agriculture in the 20th Century and Prospects for the 21st: TA 2000*. Trinidad and Tobago, 4–9 September 1994, p. 32.

Wirtu, G., Tegegne, A. and Kassa, T. 1994. Determination of accuracy of oestrus detection in zebu and crossbred cattle using plasma progesterone concentrations. P*roceedings of the 8th Conference of the Ethiopian Veterinary Association (EVA), 5–7 October 1994*, Addis Ababa, Ethiopia.

Zerbini, E., Gemeda, T., Tegegne, A., Gebrewold, A. and Franceschini, R. 1993. The effects of work and nutritional supplementation on postpartum reproductive activities and progesterone secretion in F1 crossbred dairy cows in Ethiopia. *Theriogenology* 40(3):571-584.

Annex

Annex I. List of participants on the national workshop on 'Alternatives for Improving field AI delivery system to enhance beef and dairy production in Ethiopia, from 18–19 July 2011, held at the ILRI, Addis Ababa campus.

	Name	Institution	Position
1	Bewket Siraw	ARARI	Livestock Director
2	Awot Estifanos	TARI	Livestock Director;
3	Abraham Habtu	TARI	Livestock Expert, Mekelle Centre
4	Tesfaye Alemu Aredo	OARI	Livestock Director
5	Asrat Tera Dolebo	SARI	Livestock Director
6	Getenet Assefa	EIAR	Livestock Director
7	Seyoum Bediye	EIAR	Livestock Advisor
8	Tamrat Seyoum	EIAR – Holetta	Senior researchers
9	Tamrat Degefe	EIAR – Debre Zeit	Senior researchers
10	Alemu Admassu	BoA – Amhara, Extension	Head, Extension
11	Tsegewoiyne Tekleab	BoA – Tigray	Animal Production & Forage
12	Tigabu Araya	BoA – Tigray - Livestock	Livestock Expert
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ISBN 92–9146–459-7

Livestock and irrigation value chains for Ethiopian smallholders project aims to improve the competitiveness, sustainability and equity of value chains for selected high-value livestock and irrigated crop commodities in target areas of four regions of Ethiopia. It identifies, targets and promotes improved technologies and innovations to develop high value livestock and irrigated crop value chains; it improves the capacities of value chain actors; it improves the use of knowledge at different levels; it generates knowledge through action-oriented research; and it promotes and disseminates good practices. Project carried out with the financial support of the Government of Canada provided through Foreign Affairs, Trade and Development Canada (DFATD). lives-ethiopia.org

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