NATIONAL AGRICULTURAL AND FOOD CENTRE
RESEARCH INSTITUTE FOR ANIMAL PRODUCTION NITRA

Slovak J. Anim. Sci., 56, 2023 (3): 29–43
ISSN 1337-9984, E-ISSN 1338-0095
SCICELL

ASSESSMENT OF EFFICIENCY OF ARTIFICIAL INSEMINATION SERVICE IN CATTLE PRODUCTION IN THE WESTERN ZONE OF TIGRAY REGION, ETHIOPIA

Teweldemedhn MEKONNEN*, Leul BERHE

Tigray Agricultural Research Institute; Humera Begait Animals Research Center, Tigray, Ethiopia

ABSTRACT

The study was conducted before the ignition (before October 2020) of the war in Tigray Region, Ethiopia. Artificial insemination (AI) is the first generation biotechnology and is one of the assisted reproductive techniques (ART) that greatly plays for a faster genetic improvement of farm animals. Though AI was implemented in cattle crossbreeding for many decades in Ethiopia, there is quite insignificant national output of crossbred cattle population (1.54 %). The aim of the survey was to assess the efficiency of AI service in cattle production in the Western Zone of Tigray Region, Ethiopia. Twenty (20) Kebeles and 353 small-scale farmers were purposively involved in the household face-to-face survey interview. The data were analyzed using Statistical Package for Social Sciences (SPSS), and summarized by mean, frequency and percentages. The survey indicated that the existing reproductive efficiency of cattle AI service in the Western Zone of Tigray Region, Ethiopia was extremely poor. The mean number of services per conception (NSC) was very high that could be due to mainly inappropriate heat detections. The recommended, acceptable and excellent grade of NSC fall in the range of 1−1.7. The overall conception rate at first insemination (CRFI) was also very poor (20.4 %) and thus calving rate (CR) was poor (20.5 %). About one-third (33.4 %) of the respondents indicated that cows and heifers exhibited heat in 0:01−6:00 am of the day. About 30.9 % and 28.6 % of the respondents reported that their cows and heifers were inseminated in 9−12 hours and 4−8 hours after the onset of heat, respectively. The majority (70.8 %) of the respondents did not practice controlled mating and breeding, and the first preference of 50.1 % of the respondents was natural mating. The most common source of bulls for about 34.3 % of the respondents was from neighbors and followed by own bred bulls (30.0 %). Cattle AI feasibility study and identification of AI strategic interventions should be the first focus to improve the existing poor AI efficiency of the study area.

Key words: artificial insemination; breeding program; reproduction; service number per conception; conception rate; calving rate

INTRODUCTION

The rural sedentary areas of Ethiopia are a host for about 60.4 million cattle population. About 54.7 % of the total cattle population constitutes female cattle and the remaining 45.3 % of the total population is male cattle. More than ninety-eight percent of the total cattle population in the country are local breeds whilst crossbred and pure exotic breeds accounted for about 1.54 % and 0.22 %, respectively (CSA, 2018). Zebu (*Bos indicus*) cattle have low potential for meat and milk production, and meet only 35 % of the human requirements although they are multipurpose animals (Landiver *et al.*, 1985; Mukasa-Mugerewa, 1989). The main limiting factor influencing production efficiency in dairy and beef cattle is reproduction (Diskin and Sreenan, 2000).

Artificial insemination (AI) in cattle has been commercially available at global level since the 1930's (Foote, 2002). AI has been used for genetic improvement through proven sires, keeping accurate breeding records and reducing risk of venereal disease transmission

*Correspondence: E-mail: teweldem2004@gmail.com
Teweldemedhn Mekonnen, Tigray Agricultural Research Institute,
Humera Begait Animals Research Center, Tigray, Ethiopia, P. O. Box-62

Received: August 8, 2023
Accepted: September 22, 2023

https://doi.org/10.36547/sjas.829

compared with natural mating (Hafez, 1993). The practical solution to improve the low productivity of Ethiopian indigenous cattle was by selection and crossbreeding of the indigenous cattle breeds with high-producing exotic cattle (Tadesse, 2002). Ethiopian cattle crossbreeding work was initiated in the early 1950s, and was not began based on clearly defined breeding policy with regard to the level of exotic blood inheritance and the breed types to be used. The unplanned crossbreeding had also threatened the genetic resources base of Ethiopia (Aynalem *et al.*, 2011). Crossbred dairy cattle in Ethiopia are mainly crosses of Zebu and Holstein Friesian (Nuraddis and Ahmed, 2017). Ethiopian cattle breeding is mostly uncontrolled, and genetic improvement is difficult (Tegegn and Zelalem, 2017). There are quite insignificant total numbers of crossbred female cattle produced through the crossbreeding programme for many decades in Ethiopia indicating unsuccessful crossbreeding through AI (Sinishaw, 2004; Desalegn, 2008; CSA, 2011).

Reproductive biotechnology cannot be dealt as the solution for poor management. Genetic improvement can only be attained when good practices in livestock management are practiced. Good practices in animal husbandry, animal health and nutrition, and reproduction are essential for the application of biotechnologies (Bertolini and Bertolini, 2009). AI is the first generation biotechnology and application of AI in cattle can increase up to 50 % genetic progress using either extended semen that has been preserved in liquid form (fresh, or cooled to 5 °C), or deep-frozen (Vishwanath, 2003). The use of AI had a major impact on genetic improvement programs in developed countries due to 1 up to 1.5 % annual rates of genetic gains in dairy cattle (Lohuis, 1995). However, the accuracy of oestrus detection is one of the major factors that determine the conception rate since ova remain viable for only about 12 − 18 hours after ovulation (Bekana, 1991; Rodriguez-Martinez, 2000) whereas sperm viability is only for 24 hours of its insemination (Dalton, 2011).

Number of services per conception (NSC), days open and calving interval (CI) are important reproductive traits that are crucial for determining the profitability of dairy production (Lobago *et al.*, 2007). Delayed age at sexual maturity and first calving, high NSC and longer CI are major areas of reproductive loss in cattle (Mukasa-Mugrewa, 1989; Alberro, 1983). Delayed age at first calving increases the cost of rearing and decreases lifetime milk production (Van Pelt, 2016). First service conception rate is extremely important to evaluate the percentage of pregnant females at first service (Ganchou *et al.*, 2005). NSC is significantly influenced by the genetic constitution of dairy animals, and was demonstrated in three local Ethiopian breeds which comprised the Barka, Horro and Boran and crossbred cows (Azage *et al.*, 1981).

Reproductive failure is a major source of economic loss in dairy and beef industry (Perry, 2005). The efficiency of AI service in Ethiopia is at a very low level due to low accessibility of infrastructure, managerial and financial constraints, poor heat (oestrus) detection, improper timing of insemination and death of embryo (Shiferaw *et al.*, 2003; Tesfaye *et al.*, 2015). Undetected oestrus, low AI-submission rates, and long inter-breeding intervals are the main contributors to poor reproductive efficiency (Ambrose and Colazo, 2007). Artificial insemination technicians (AITs) are also vital in semen handling and performing inseminations (Boettcher and Perera, 2007). There are reproductive management tools such as oestrus synchronization that involves induction of oestrus in a group of females to breed relatively in around the same time (Schafer *et al.*, 2007; Rick, 2013). This reproductive technique can help in improving overall reproductive performances of cows.

Tesfay *et al.* (2019) reported on the assessment and analysis of the participatory agricultural production constraint appraisal of the Western Zone of Tigray, Ethiopia, and it was noted that efficiency of cattle AI service was unknown. Moreover, the small-scale farmers were complaining about the efficiency of cattle AI service. Assessment of the practical implications on the efficiency of cattle AI service was compulsory. Therefore, the objective of this assessment was to know the information on the efficiency of cattle AI service, mating practices, insemination times, insemination time practice of AITs, and awareness of farmers on oestrus synchronization in cattle breeding and production.

MATERIAL AND METHODS

Description of the study areas

The survey was carried out in Kafta Humera, Tsegede and Welkait districts of Tigray Region, Ethiopia. Kafta Humera district has two agro-ecologies which consist of 85.7 % lowland (*kola*) and 14.3 % midland (*weina dega*). Welkait district has also two agro-ecologies which include 60 % lowland (*kola*) and 40 % midland (*weina dega*). Tsegede district has three agro-ecologies which comprise 69.5 % lowland (*kola*), 21.7 % midland (*weina dega*) and 8.6 % high land (*dega*). Kafta Humera district is characterized by an altitude of 500 − 1849 meters above sea level (masl), rainfall of 650 − 750 millimeters (mm) and temperature of 25 − 48 °C. Welkait district is characterized by an altitude of 700-2354 masl, rainfall of 700 − 1800 mm and temperature of 17.5 − 25 °C. Tsegede district is also characterized by an altitude of 680 − 3008 masl, rainfall of 1200 − 2500 mm and temperature of 12 − 35 °C (Tesfay *et al.*, 2019).

Kafta Humera district is the lowland part of the Western Zone of Tigray Region, Ethiopia whereas Welkait and Tsegede districts are the highland areas of the Western Zone of Tigray. The land use types of Kafta Humera district include arable land (54.19 %), forestry land (33.44 %), pasture land/grazing land (5.13 %) and other land use type (8.08 %), and the soil types of the district are vertisol (90 %), loam (5 %), sandy soil (5 %). The land use types of Welkait district are cultivated land (38.82 %), grazing land (18.04 %), forest land (18.83 %), housing (4.69 %) and mountain and rugged land (19.62 %), and the soil types of the district are clay (35.7 %), silt (40.8 %) and silt loam (23.5 %). Arable land (93 %), forest land (34.9 %), grazing land (22 %), bush (8.65 %), shrubs (3.7%), settlement (8.6 %) and others (9.29 %) are the land use types of Tsegede district, and the soil types of Tsegede district are clay (47.2 %), sand (33.6 %) and silt (19.2 %) (Tesfay *et al.*, 2019).

Data collection

Sample size, sampling technique and data collection methods

The survey was conducted in twenty (20) rural and peri-urban Kebeles, 353 small-scale farmers and 10 AITs, and purposive sampling was used to select Kebeles (lowest administrative units), households (small-scale farmers) and AITs. Kebeles with more cattle AI service beneficiaries and households who bred animals two years and above were involved in the face-to-face survey interview. The study Kebeles were categorized as lowland, midland and highland agro-ecologies. The cattle genotypes in the small-scale farmers were Arado cattle, Begait cattle and HF crossbred cattle. The AI service of the crossbreeding program in Tsegede and Welkait districts was mainly crossbreeding of Holstein Friesian (HF) and Arado cattle whereas the AI service in Kafta Humera district was pure breeding of Begait cattle.

A structured questionnaire was used to collect the data from each household. The type of cattle AI service consisted of conventional AI service and oestrus synchronization followed by mass AI service program. Household characteristics, number of inseminated cows and heifers, NSC, number of conceived cows and heifers, number of calves born, mating practices, importance of AI, and awareness and importance of oestrus synchronization in cattle breeding were the types of data collected.

Statistical analysis

Statistical Package for Social Sciences (SPSS) (SPSS, 2012) software was used to analyze the data. The data were summarized using descriptive statistics (frequency, percentage and mean). Overall conception rate (CoR) was calculated from first time, second time and third time inseminations.

Moreover, an asymptotic Chi-Square test (X^2-test) was computed to test for assessing if a sample proportion differs from a specified proportion. One-way ANOVA was also employed to test whether there existed a significant difference ($P < 0.05$) in the number of cows and heifers inseminated and calved across the cattle AI service delivery years.

RESULTS

Household characteristics

About 92.9 % of the household heads (HHs) interviewed were males. The mean household family size was 6.04 ± 1.993. About 45.3 % of the interviewed HHs attended lower primary school whereas 30.6 % of the HHs interviewed were illiterate. The dominant cattle of the households interviewed were Arado cattle and very few HF crossbred cattle were introduced to the small-scale farmers. Extensive production system (88.4 %) was the production system followed by the households interviewed while very few (7.1 %) of the households followed small-scale the intensive production system (Table 1).

Table 1. Household livestock holding numbers

Livestock type (n = 353)	Mean ± SD
Begait cattle holding (N)	3 ± 8
Arado cattle holding (N)	4 ± 6
HF cattle holding (N)	0 ± 1
Begait and Arado crossbred cattle holding (N)	2 ± 5
HF and Fogera crossbred cattle holding (N)	0 ± 3
Goats holding (N)	7 ± 17
Sheep holding (N)	6 ± 29
Donkeys holding (N)	1 ± 1
Chicken holding (N)	7 ± 13
Traditional beehive holding (N)	0 ± 3
Modern beehive holding (N)	0 ± 4

n = number of respondents, N = number of animals, SD = standard deviation

Table 2a. Description of temporal (2013 through 2018) efficiency of cattle AI service

Reproductive parameters	Temporal efficiency of AI (Mean)						Overall mean
	2013	2014	2015	2016	2017	2018	
NSC[1]	1.9	1.4	1.6	1.6	1.4	1.7	1.6
NSC[2]	4.9	3.6	5.7	5.5	5.2	4.2	4.8
CRFI (%)	17.4	28.0	16.6	17.6	20.0	24.0	20.4
CoR (%)	22.6	30.5	19.8	19.9	21.5	27.2	23.1
CR	20.3	27.5	17.6	17.9	19.4	23.1	20.5

NSC[1] = mean number of first AI services per conception, NSC[2] = mean number of all annual AI services provided per conception, CRFI = conception rate at first insemination, CR = calving rate, CoR = conception rate at first time, second time and third time inseminations

Table 2b. Statistical One-way ANOVA description of efficiency of cattle AI service across years

Reproductive traits	Groups	Sum of squares	df	Mean square	F	*P* value
Number of cows and heifers inseminated	Between groups (y)	17.617	5	3.523	1.140	0.337
	Within groups (y1)	2586.421	837	3.090		
	Total	2604.038	842			
Number of cows and heifers calved	Between groups	3.378	5	0.676	1.375	0.231
	Within groups	411.241	837	0.491		
	Total	414.619	842			

y = between service years, y1 = within a unit of service year, $P < 0.05$

Temporal (2013-2018) success rate of cattle AI service

ANOVA indicated that there was no significant difference (*P* > 0.05) among years in the number of inseminated cows and heifers and the number of cows and heifers calved (Table 2). The overall calving rate (CR) from 2013 through 2018 was 20.5 %. The return rate (repeat breeding) of cows and heifers (79.6 %) and the mean number of all annual services per conception (NSC) were very high (4.8) revealing poor reproductive performances of cows and heifers. The conception rate at first insemination (CRFI) (20.4 %) and CR (20.5 %) were very poor (Table 2). Hence, the efficiency of cattle AI service in the reproduction and production of cattle in the study area was extremely poor.

Table 3. Importance of AI in cattle breeding and production

Importance of AI		Frequency (%)	X^2	*P* value
Yes, AI is important		186 (52.7)	1.023	0.312
No, AI is not important		167 (47.3)		
Importance of AI service versus district cross tabulation				
Kafta Humera	yes	69 (19.5)	15.003	0.001
	no	83 (23.5)		
Tsegede	yes	81 (22.9)		
	no	40 (11.3)		
Welkait	yes	36 (10.2)		
	no	44 (12.5)		
If yes, the likert grade of AI service				
Satisfactory		117 (33.1)	40.816	0.000
Very satisfactory		69 (19.5)		
No importance		167 (47.3)		

Numbers in parentheses are the percent of respondents.

Table 4. When do cows mostly show heat and when does the AIT inseminate your cows?

Time cows mostly showed heat 24 hours clock categories	Frequency (%)	X^2	*P* value
0:01 – 6:00 am	118 (33.4)	14.649	0.002
6:01 – 12:00 am	71 (20.1)		
12:01 – 18:00 pm	86 (24.4)		
18:01 – 24:00 pm	78 (22.1)		
Insemination time (farmers response)			
4 – 8 hours after heat sign	101 (28.6)	104.776	0.000
9 – 12 hours after heat sign	109 (30.9)		
13 – 24 hours after heat sign	93 (26.3)		
25 – 48 hours after heat sign	12 (3.4)		
Unknown time	38 (10.8)		
Insemination time (AITs response)			
4 – 8 hours after heat sign	8 (80)		
9 – 12 hours after heat sign	1 (10)		
13 – 24 hours after heat sign	1 (10)		

Importance of cattle AI service, and practices of insemination time and controlled breeding

Cattle AI service was not statistically significant ($P > 0.05$) in breeding, reproduction and production in the study area. However, cattle AI service was important and significantly different ($P < 0.05$) among the districts (Table 3). It was noted that there was a highly significant correlation ($P < 0.01$) between agro-ecology and economic importance of cattle AI service in the study area. About one-third (33.4 %) of the respondents indicated that cows mostly show heat in 0:01 – 6:00 am. Insemination time was variable in that

Table 5. Practice of controlled breeding and mating, comparison of mating method and most common source of bull and AM/PM method of insemination time

Controlled breeding and mating	Frequency (%)	X^2	*P* value
Yes	103 (29.2)	61.215	0.000
No	250 (70.8)		
Comparison of mating method			
AI only	8 (2.3)	273.983	0.000
Natural mating only	177 (50.1)		
Combination of AI and natural mating	34 (9.6)		
AI with oestrus synchronization	104 (29.5)		
Natural mating with oestrus synchronization	30 (8.5)		
Most common source of bull (Natural Service)			
Own bred	106 (30.0)	157.184	0.000
Selected from neighbor	121 (34.3)		
Bought from market	2 (0.6)		
Unknown bull	97 (27.5)		
No use of natural mating	27 (7.6)		
AM/PM method of insemination time (famers response)			
Yes	204 (57.8)	8.569	0.003
No	149 (42.2)		
AM/PM method (AITs response)	10 (100)		

Table 6. Frequency (%) of awareness of farmers on oestrus synchronization and its importance

Awareness on oestrus synchronization		Importance of oestrus synchronization (farmers response)		X^2	*P* value	Importance of oestrus synchronization (AITs response)	
Response	Frequency (%)	Likert grade	Frequency (%)	229.649	0.000	Very poor	4 (40)
Yes, I have awareness	307 (87.0)	Very poor	51 (14.4)			Poor	1 (10)
No, I do not have awareness	46 (13.0)	Poor	25 (7.1)			Satisfactory	5 (50)
		Satisfactory	48 (13.6)				
		Very satisfactory	183 (51.8)				

30.9 % of the respondents inseminated their animals in 9 – 12 hours after their heat sign whilst 10.8 % of the respondents inseminated their animals at unknown time (Table 4). The practice of controlled breeding and mating was very poor (29.2 %). About half (50.1 %) of the respondents selected natural service followed by AI with oestrus synchronization (29.5 %). When the small-scale farmers used natural service, the most common bull source was selected from neighbors (34.3 %). A significant amount of the respondents (27.5 %) used unknown bulls. Most (57.8 %) of the respondents signposted that the antemeridian/postmeridian (AM/PM) method of insemination was followed during the insemination times of cows and heifers (Table 5).

Awareness and importance of oestrus synchronization in cattle breeding

The majority (87.0 %) of the small-scale farmers were acquainted with oestrus synchronization, however, 14.4 % and 7.1 % of the small-scale farmers graded the importance of oestrus synchronization in cattle breeding as very poor and poor, respectively (Table 6). About 40 % of the AITs reported that oestrus synchronization was very poor in cattle breeding. Oestrus detection was made by visual observation, and pregnancy diagnosis was made by the state of heat return rates of cows and/or heifers.

DISCUSSION

Begait cattle from the Zebu group (*Bos indicus*) (3 ± 8) and Arado cattle from the Zenga group (4 ± 6) were the major breeds owned by the households interviewed. The present mean number of all annual services per conception (NSC) (4.8) is not comparable and higher than the recommendations on NSC for profitable dairy cows. The NSC of the study area was very high mainly due to inappropriate heat detections. This reason is confirmed from the analysis of mean number of first AI services per conceived cows and heifers (1.6) and mean number of all annual AI services provided per conception (4.8). NSC of 4.8 is very much higher than and not comparable with 1.8 in crossbred dairy cows under farmers' management in and around Debre Zeit, Ethiopia (Niraj *et al.*, 2017), 1.8 in crossbred cows (Tadesse *et al.*, 2010), 1.7 in the highlands of Ethiopia (Lobago *et al.*, 2007), 1.3 in crossbred cows in Gondar city of Ethiopia (Nibret, 2012), 1.52 in crossbred dairy cows under smallholder condition in Assela town of Oromia Region of Ethiopia (Hunduma, 2012), 1.56 in Zebu and Holstein-Friesian crossbred dairy cows in Jimma town of Oromia Region of Ethiopia (Belay *et al.*, 2012a), 1.62 in crossbred dairy cows in different production systems in the central Highlands of Ethiopia (Shiferaw *et al.*, 2003), 1.67 in crossbred dairy cattle under smallholder conditions in and around Zeway, Ethiopia (Yifat *et al.*, 2009), 1.88 ± 0.07 in different indigenous breeds of Ethiopia (Desalegn, 2008), 1.28 in Fogera (Menale *et al.*, 2011), 1.8 in Horro and Jersey crossbred (Demissu *et al.*, 2014), 1.56 in Native and Friesian crossbred (Belay *et al.*, 2012b), 1.60 ± 0.04 (urban production system) and 1.73 ± 0.04 (peri-urban production system) in HF and Zebu crossbred cows in Eastern Zone of Tigray, Ethiopia (Alemshet *et al.*, 2017), 2.1 ± 1.1 in Horro and 1.8 ± 0.9 in Horro and Jersey crossbred (Demissu *et al.*, 2013), 1.8 ± 0.3 in Holstein Friesian (HF) crossbred and indigenous cows, 2.2 ± 0.2 in indigenous cows and 1.5 ± 0.3 in HF crossbred (Niraj *et al.*, 2014), 1.8 in crossbred cows (Niraj *et al.*, 2017), 1.50 ± 8.08 in local cows, 1.54 ± 5.48 in crossbred of local and Friesian, 1.31 ± 6.07 in crossbred of local and Sahiwal, 1.23 ± 6.78 in crossbred of local and Sahiwal and Friesian and 1.15 ± 9.66 in crossbred of local and Jersey (Akhtarul *et al.*, 2016), 1.64 ± 0.77 in Peranakan Ongole cattle kept in lowland on-farm, 1.66 ± 0.68 in crossbred of Limousin and Peranakan Ongole cattle kept in lowland on-farm and 1.94 ± 0.89 in Peranakan Ongole cattle kept in highland on-farm condition of Indonesia (Suyadi *et al.*, 2014), and 1.56 in Fogera and Holstain Friesian crossbred dairy cows in Debre Tabor town, Ethiopia (Sena *et al.*, 2014). The variations in NSC could be due to differences in genotype, animal age, animal body condition, parity, heat detection, management system, ecology, awareness of famers, season of insemination, insemination time, presence or absence of oestrus induction, semen handling procedures and semen quality.

There are other AI efficiency investigations where the present mean NSC (4.8) is very much higher than the mean NSC 1.34 ± 0.67 in indigenous cows and 1.31 ± 0.55 in crossbred cows kept under on farm condition in Southern Zone of Tigray, Ethiopia (Mebrahtom and Hailemichael, 2016), 1.602 ± 0.19 in local x (local x Friesian), 1.8 ± 0.21 in local x Jersey, 1.72 ± 0.17 in (local x Hariana) x Friesian and 1.83 ± 10.21 in (local x Jersey) x (local x Jersey) (Islam *et al.*, 2017), 2.2 in Native cows (Kumar *et al.*, 2014), 2.1 in Horro (Demissu *et al.*, 2014), 2.47 in Tigray, Ethiopia AI service (Desalegn, 2008), 2.01 ± 0.2 in

Friesian x Arsi (F1) (Negussie *et al.*, 1998), 2.1 ± 0.2 in Friesian x Zebu (Ermed, 2004), 2.16 in Friesian x Zebu (Mureda and Mekuriaw, 2007), 2.2 ± 0.2 in indigenous cows (Niraj *et al.*, 2014), 1.74 in indigenous cows (Seblewengel *et al.*, 2018), 1.4 in central Uganda (Mugisha *et al.*, 2014), 2.05 ± 1.47 in HF dairy cows at Holeta Genesis farms (Alewya, 2014), 1.52 ± 0.9 in smallholder crossbred dairy cows (Tafari, 2016), 1.44 ± 0.04 in Zebu and HF and Zebu crossbred kept under smallholder condition (Ali *et al.*, 2015), 1.38 in cows bred through Fixed Time Artificial Insemination (FTAI) in Bangladesh (Shankar *et al.*, 2017), 1.37 in beef cattle under smallholder farmers of Pohuwato Regency of Indonesia (Mukhtar *et al.*, 2019), 1.60 in selected districts of smallholder dairy cows of Harar, Ethiopia (Engidawork, 2018), 1.91 in West Shoa Zone by single and double injections hormonal treatment of PGF2ὰ (Bainesagn, 2015), 1.75 in dairy cattle bred by FTAI (1.85 in local cows and 1.44 in crossbred cows) in Southern Region, Ethiopia (Debir *et al.*, 2016a). They are the same reasons that the variations in NSC could be due to the differences in genotype, animal age, animal body condition, parity, heat detection, management system, ecology, awareness of famers, season of insemination, insemination time, presence or absence of oestrus induction, semen handling procedures and semen quality. Appropriate and timely heat detection and insemination are among the major factors to lower or higher NSC. Majority of the study area has high environmental temperature, and NSC may be highly influenced by the high environmental temperature.

The present result on conception rate at first insemination (CRFI) is extremely poor (20.4 %) compared with 65 % reported by Hunduma (2012), 61.7 % reported by Azage *et al.* (2012) for oestrus synchronized cows in Adigrat and Mekelle milk shed, 58.6 % in Adami-Tullu HF and Zebu crossbred and 54.15 % in North Gondar Zone HF and Zebu crossbred reported by Haileyesus (2006), 41.6 % in Iran reported by Ansari-Lari *et al.* (2010), 45.9 % in Eastern lowlands of Ethiopia reported by Emebet and Zeleke (2014); CRFI on conventional cattle AI service at national level (27.06 ± 0.44 %), in Addis Ababa (40.23 % ± 0.50), and in Tigray Regional State, Ethiopia (32.08 %) reported by Desalegn (2008); Heins (2007) reported on Holsteins and Jersey and Holstein crossbreds values of 41 % and 39 %, respectively. Heins *et al.* (2006) reported previous experiences on Holstein (22 ± 3.0 %), Normande (35 ± 3.0 %), Monbeliarde x Holstein (31 ± 3.0 %) and Scandinavian Red x Holstein (30 ± 3.0 %) in commercial herds of California, and HF and Zebu crossbred cows in Eastern Zone of Tigray, Ethiopia (64.6 ± 1.06 %) reported by Alemshet *et al.* (2017).

Tegegn and Zelalem (2017) report of 24.69 % through FTAI, 40.9 % in Zebu and HF and Zebu crossbred kept under smallholder condition reported by Ali *et al.* (2015); 52.11 % in cows bred through FTAI in Bangladesh (Shankar *et al.*, 2017), 66.67 % in beef cattle under smallholder farmers of Pohuwato Regency of Indonesia (Mukhtar *et al.*, 2019), 39.3 % through FTAI (Gizaw *et al.*, 2016), 34.29 % in Oromia through FTAI (Legesse, 2015), 49.17 % in Dangi cows, 41.36 % in HF crossbred cows in smallholders of India (Potdar *et al.*, 2016), 48.1 % in in selected districts of smallholder dairy cows of Harar, Ethiopia (Engidawork, 2018), and 60.4 % in dairy cattle bred by FTAI (54.0 % in local cows and 69.6 % in crossbred cows) in Southern Region, Ethiopia (Debir *et al.* 2016b) are higher than and not comparable with the present CRFI (20.4 %). The differences in CRFI could be due to the differences in ecology, husbandry practices, presence or absence of oestrus induction, climate change, genotype, heat detection skills, efficiency of inseminators, fertility level, semen quality, semen handling procedure and time of insemination. The present CRFI (20.4 %) is higher than the previous work in Tigray Region, Ethiopia (7.14 % ± 0.85) reported by Desalegn (2008).

The CRFI (20.4 %) is not comparable with the report on local and crossbred dairy cows (46.2 %) kept under smallholder in Sodo Zuria District, Ethiopia (Abiyot and Eyob, 2019), 73.8 % in Zebu and HF and Zebu crossbred kept under smallholder condition (Ali *et al.*, 2015), 54.54 % in cows bred through FTAI in Bangladesh (Shankar *et al.*, 2017), 56 % in dairy cows of Eastern and Southeastern Zones of Tigray, Ethiopia (Ashebir *et al.*, 2016), and 64.8 % in dairy cows in and around Bishoftu, Oromia Regional State, Ethiopia (Belete *et al.*, 2018). They are the same reasons that the differences could be due to the differences in ecology, husbandry practices, presence or absence of oestrus induction, climate change, genotype, heat detection skills, efficiency of inseminators, fertility level, time of insemination, semen quality and handling procedures. However, the present finding on CRFI (20.4 %) is comparable with the CRFI of 24.69 % in dairy cattle bred by FTAI in Mizan Aman area, Bench Maji zone, South West Ethiopia (Tegegn and Zelalem, 2017) and 24.69 % in cows and heifers of South West Ethiopia bred by FTAI (Teddy, 2017).

Calving rate (CR) was defined as the number of calves born per 100 services and is the most appropriate measure of fertility (Mohamed, 2004). The present result on CR (20.5 %) is much below the findings of Alemshet *et al.* (2017) in HF and Zebu crossbred cows (54.8 ± 1.35 %) in Eastern Zone of Tigray, Ethiopia, Emebet and Zeleke (2014) and Haileyesus (2006) reported in crossbred dairy cows (63.4 to 76.9 %) in different parts of the country, 26.22 % in South West Shoa Zone of Oromia, Ethiopia through FTAI (Fekata *et al.*, 2020), 39 % in smallholder dairy herd bred by conventional AI in Kenya (Kinyua, 2016), and 37 % in dairy cows of Eastern and Southeastern Zones of Tigray, Ethiopia (Ashebir *et al.*, 2016). Though the present result on CR is too low (20.5 %), it excels 13.58 % of CR in dairy cattle bred by FTAI in Mizan Aman area, Bench Maji Zone, South West Ethiopia reported by Tegegn and Zelalem (2017), 10.67 % CR through FTAI reported by Dereje (2018), and 13.58 % in cows and heifers of South West Ethiopia bred by FTAI (Teddy, 2017). Calving rate is the reproductive factor that follows conception rate. As per the definition of calving rate, the variations could be due to differences in genotype, animal age, animal body condition, parity, heat detection, management system, ecology, awareness of famers, season of insemination, presence or absence of oestrus induction, insemination time, semen handling procedures and semen quality, and psrevalence of reproductive diseases.

Majority of the study area has high environmental temperature. Heat stress causes 20 to 30 % reduction in conception rate and pregnancy rate (Khan *et al.*, 2013; Schuller *et al.*, 2014). About 96 % of the variation in conception rate is due to management and environmental factors. Conception rate is influenced by herd differences in nutrition, metabolic disorders, reproductive health, heat detection, insemination practices and climate change. About 4 % of the variation in conception rate is due to genetic factors with 3 % for the cow and 1 % for the service bull (Kathy, 2004).

Cattle AI service programme was not significantly (P > 0.05) important in the Western Zone of Tigray, Ethiopia because 47.3 % of the small-scale farmers were not satisfied by the cattle AI service programme. However, the present report is not similar with the reports of Kindalem (2019) reported that 94.0 % of AI beneficiaries in Janamora district were not satisfied by the AI service; Gebremedhin (2008) reported the respondents in Tiyo (31 %) and Sagure (45.5 %) districts of Arsi Zone were satisfied with AI service; 55.8 % of the respondents were not satisfied by AI service (Riyad *et al.*, 2017); Desalegn (2008) reported that 93.1 % of the AI beneficiary farmers did not get reliable and consistent AI service and were not satisfied; 69.17 % of the respondents in West Gojjam Zone were not satisfied in AI service (Malede *et al.*, 2013); 69.9 % respondents in Debretabour Town, Ethiopia were not satisfied by AI service (Bemrew *et al.*, 2015); Getabalew *et al.* (2019) reported that there is little or no satisfaction on AI service delivery system by most smallholder dairy farmers in many places of Ethiopia, and 67.15 % of the respondents in South West Shoa Zone of Oromia, Ethiopia were not satisfied on oestrus synchronization and mass AI service (Fekata *et al.*, 2020). The differences in AI service satisfaction level in different parts of the country could be due to lack of awareness, efficiency of AITs, oestrus detection, ecology, husbandry practices, semen quality and semen handling procedures and overall efficiency of AI service. Therefore, there is an overall national problem in the efficiency of cattle AI service and needs improvement in the AI service delivery system. Ashebir *et al.* (2016) reported that the efficiency of AI in the Tigray Region, Ethiopia seems satisfactory because a calving rate of 37 % was achieved and only 27.6 % of the smallholders in Eastern and Southeastern Zones of the Region were not satisfied by the overall efficiency of AI service.

About one-third (33.4 %) of the cows and heifers in the Western Zone of Tigray, Ethiopia exhibited heat in the time of 0:01 – 6:00 am. This report is not in line with the work of Ashebir *et al.* (2016) who reported that majority (52.89 %) of dairy cows in Eastern and Southeastern Zones of Tigray showed heat in the evening hours. The difference could arise from the differences in genotype, ecology, husbandry practices, management system and environmental weather conditions.

Most of the respondents indicated that cows and heifers in the Western Zone of Tigray, Ethiopia were inseminated in 9 – 12 hours (30.9 %) and 4 – 8 hours (28.6 %) after the onset of oestrus. Moreover, 10.8 % of the respondents reported that cows and heifers were inseminated at unknown time. The present insemination time is not in line with Belete *et al.* (2018) who reported the conception rate of local and crossbred cows inseminated at 10 – 24 hours after the onset of oestrus was significantly higher (82.2 %) than those inseminated at 24 – 48 hours (32.8 %) and before 10 hours (36.4 %) after onset of oestrus; Das *et al.* (2010) who reported the conception rate of Red Chittagong cows was higher (74.19 %) when inseminated at 10 − 14 hours after onset of oestrus than the conception rate (50 %) cows inseminated at 6 − 10 hours. Debir *et al.* (2016b) reported the optimum conception rate (71.6 %), among the cows inseminated, between 9 − 14 hours after the onset of oestrus whilst the lower conception rate was observed (12.5 %) in 19 − 24 hours after the onset of oestrus. The differences could be due to husbandry practices, ecology, genotype, management system and weather conditions. For example, majority of the cows and heifers included in this study were from a habitat with high environmental temperature (reach up to 48 °C) which is beyond the recommendation of Todd (2012) who recommended oestrus behavior was greatest in dairy cows observed twice daily when ambient temperatures were less than 25 °C.

About 50.1 % of the small-scale farmers in the present survey appreciated natural mating compared to other methods. This is in line with communal grazing land is the main source of breeding bull in most parts of Ethiopia where most farmers practiced natural, unplanned and uncontrolled mating system (Ayantu et al., 2012; Debir, 2016b). In dairy cattle breeding, most of the dairy farmers in the highland, midland and the lowland areas of Ethiopia used natural mating by using indigenous breeding bull (Tesfa, 2009). About 88.4 % of the respondents in the Western Zone of Tigray, Ethiopia managed their animals under extensive management system. This is similar with Ayantu *et al.* (2012) and Azage *et al.* (2013) studies that uncontrolled mating predominates under the extensive livestock husbandry system especially in the rural areas, and Desta (2002) reported that many farmers in Ethiopia prefer natural mating to AI service due to the conception results from the AI services are poor.

CONCLUSION

Artificial insemination (AI) service is the most important and widely practiced reproductive biotechnology all over the world. However, the efficiency of cattle AI service in the Western Zone of Tigray, Ethiopia was very poor mainly due to inappropriate heat detections. Hence, small-scale farmers were not satisfied by the AI service due to different challenges including inappropriate heat detections. The participation of female headed households in cattle AI service was extremely poor. Cattle AI service in the study area was highly influenced by agro-ecology in that AI success rate was high in the highland areas as compared to the lowland agro-ecology.

AI feasibility study should be the first research activity in the future in the study area because the present efficiency of cattle AI service is very poor. Therefore, the present efficiency of cattle AI service calls urgent measures in identification and application of strategic interventions which improve the existing poor AI service efficiency. Oestrus synchronization solves oestrus detection problems and is essential in the improvement of reproductive efficiency of cattle. However, some small-scale farmers and AITs reported that oestrus synchronization was not important. Therefore, research and development organizations should take a concern on the identification of the appropriate agro-ecology based oestrus synchronization protocols. After the completion of the AI feasibility study of the area, cattle AI service should be practiced based on community based breeding and improvement approach; dispersed breeding should be avoided. The community should be provided adequate and frequent training to enhance the efficiency of cattle AI service. Many stakeholders should be involved in cattle AI service. Furthermore, semen storage, quality control and delivery methods should be critical concerns in the future.

ACKNOWLEDGEMENTS

The authors would like to thank to Agricultural Growth Program Π (AGP- Π) and Humera Agricultural Research Center for their financial and transport supports.

AUTHOR'S CONTRIBUTIONS

Conceptualization: Mekonnen, T.

Methodology: Mekonnen, T.

Investigation: Mekonnen, T., Berhe, L.

Data curation: Mekonnen, T.

Writing-original draft preparation: Mekonnen, T.

Writing-review and editing: Mekonnen, T., Berhe, L.

Project administration: Mekonnen, T.

All authors have read and agreed to the published version of the manuscript.

DATA AVAILABILITY STATEMENT

The data presented in this study are available on request from the corresponding author.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

REFERENCES

Abiyot, H. & Eyob, E. (2019). Evaluation on the Efficiency of Artificial Insemination Following Estrus Synchronization of Dairy Cattle: In the Case of Sodo Zuria District, Ethiopia. *EC Veterinary Science*, 4(4), 226−233.

Akhtarul, I., Jalal, U. S., Syed, S. J. & Hemayatul I. (2016). Evaluate the Productive and Reproductive Performance Considering Genotypes of Dairy Cows. *International Journal of Nutrition and Food Sciences. Special Issue: Analytical and Microbiological Characterization of Antimicrobial Peptides*, 5, 10−15. DOI: 10.11648/j.ijnfs.s.2016050601.13

Alberro, M. (1983). Comparative performance of F1 Friesian x Zebu heifers in Ethiopia. *Animal Production*, 37, 247−252.

Alemshet, B., Weldegerima, K. & Yoseph, M. (2017). Reproductive Efficiency of Crossbred (HF x Zebu) Dairy Cows under Artificial Insemination Service in Eastern Zone of Tigray, Northern Ethiopia. *International Journal of Basic and Applied Biology*, 4(3), 60−163.

Alewya, H. (2014). *Comparative Study of Reproductive and Productive Performance of Holstein Friesian Dairy Cows at Holetta Bull Dam Station and Genesis Farms.* MSc. Thesis, Addis Ababa University, Ethiopia.

Ali, T., Lemma, A. & Yilma, T. (2015). Effect of Management Practices on Reproductive Performance of Smallholder Dairy Cattle. *Austin Journal of Veterinary Science & Animal Husbandry*, 2(3), 1015.

Ambrose, D. J. & Colazo, M. G. (2007). Reproductive status of dairy herds in Alberta: a closer look. *Advances in Dairy Technology*, 19, 227–244.

Ansari-Lari, M., Kafi, M., Sokhtanlo, M. & Ahmadi, H. N. (2010). Reproductive performance of Holstein dairy cows in Iran. *Tropical Animal Health and Production*, 42(6), 1277−1283.

Ashebir, G., Birhanu, A. & Gugsa, T. (2016). Status of Artificial Insemination in Tigray Regional State, "Constraints and Acceptability under Field Condition". *Journal of Dairy, Veterinary and Animal Research*, 3(3), 1−6.

Ayantu, M., Haile, A., Dessie, T. & Mekasha, Y. (2012). On farm characterization of Horro cattle breed production systems in western Oromia, Ethiopia. *Livestock Research for Development*, 24(100). http.//www.lrrd.org/lrrd24/6/meko24100.htm.

Aynalem, H., Workneh, A., Noah, K., Tadelle, D. & Azage, T. (2011). *Breeding strategy to improve Ethiopian Boran cattle for meat and milk production*. IPMS (Improving Productivity and Market Success) of Ethiopian Farmers Project Working Paper 26. Nairobi, Kenya, ILRI.

Azage, T., Galal, E. S. E. & Beyene, K. (1981). A study on the reproduction of local zebu and F1 crossbred (European x zebu) cows. I. Number of services per conception, gestation length and days open till conception. *Ethiopian Journal of Agricultural Sciences*, 3, 114.

Azage, T., Awet, E. Asrat, T. & Hoekstra, D. (2012). *Technological option 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.

Azage, T., Gebremedhin, B., Hoekstra, D., Belay, B. & Mekasha, Y. (2013). *Smallholder dairy production and marketing systems in Ethiopia.* IPMS experiences and opportunities for market-oriented development. IPMS of Ethiopian Farmers Project Working Paper 31. Nairobi. ILRI.

Bainesagn, W. (2015). *Assessment of Breeding Practices and Evaluation of Estrus Synchronization and Mass Insemination Technique in Dairy Cattle in West Shoa Zone*. MSc. Thesis, Haramaya University, Ethiopia.

Bekana, M. (1991). *Farm animal obstetrics*. Monograph, Addis Ababa University, Ethiopia, pp. 1−12.

Belay, D., Azage, T. & Hegde, B. P. (2012a). Smallholder livestock production system in Dandi district, Oromia Regional State, central Ethiopia. *Global Veterinaria*, 8(5), 472−479.

Belay, D., Yisehak, K., Janssens, G. P. J. (2012b). Productive and Reproductive Performance of Zebu X Holstein-Friesian Crossbred Dairy Cows in Jimma Town, Oromia, Ethiopia. *Global Veterinaria*, 8(1), 67−72.

Belete, Y., Abraham, J., Abebe, A., Atilaw, W. & Alemayehu, H. (2018). Factors Affecting the Efficiency of Artificial Insemination in Dairy Cows in and Around Bishoftu (Debre Zeite), Oromia Regional State, Ethiopia. *Journal of Reproduction and Infertility*, 9(2), 28–35.

Bemrew, A., Alazar, W., Anmaw, S. & Saddam, M. (2015). Assessment of Problems Associated with Artificial Insemination Services in Dairy Cattle in Debretabour Town, Ethiopia. *Journal of Reproduction and Infertility*, 6(2), 48–55.

Bertolini, M. & Bertolini, L. R (2009). Advances in reproductive technologies in cattle: from artificial insemination to cloning. *Revista de la Facultad de Medicina Veterinaria y de Zootecnia*, 56, 184–194.

Boettcher, P. J. & Perera, B. M. (2007). Improving the Reproductive Management of Smallholder dairy cattle and the Effectiveness of Artificial Insemination: A Summary. In the Reproductive Management of Dairy Cattle Subjected to AI, IAEA, Vienna. ISBN 92-0-114806-2

CSA (Central Statistical Agency). (2011). *Ethiopian Agricultural sample survey 2010/11. Report on livestock and livestock characteristics*. Central Statistical Authority (CSA), Addis Ababa, Ethiopia, 2(502).

CSA. (2018). *Ethiopian Agricultural Sample Survey. Report on Livestock and Livestock Characteristics (Private Peasant Holdings)*. Volume II, Statistical Bulletin, 587, Addis Ababa, Ethiopia.

Dalton, J. C. (2011). Strategies for Success in Heat Detection and Artificial Insemination. *WCDS Advances in Dairy Technology*, 23, 215–229.

Das, N. G., Mufti, M. M. R., Alam, M. K., Sarker, M. S. & Bostami, A. B. M. R. (2010). Study on Factors Affecting the Conception Rate in Red Chittagong Cows. *Bangladesh Journal of Animal Science*, 39(1–2), 52–57.

Debir, L. B. (2016b). A Review on Dairy Cattle Breeding Practices in Ethiopia. *Journal of Biology, Agriculture and Healthcare*, 6, 7.

Debir, L. B., Asrat, T. & Azage, T. (2016a). Evaluating the Efficiency of Artificial Insemination Following Estrus Synchronization of Dairy Cattle in Southern Region, Ethiopia: The Case of Dale District. *Journal of Natural Sciences Research*, 6(5), 22–27.

Demissu, H., Fekadu, B. & Gemeda, D. (2013). Early Growth and Reproductive Performances of Horro Cattle and thier F1 Jersey Crosses in and around Horro-Guduru Livestock Production and Research Center, Ethiopia. *Science, Technology and Arts Research Journal*, 2(3), 134–141.

Demissu, H., Fekadu, B. & Gemeda, D. (2014). Dairy Productive Potential, Challenges and Production opportunities of Horro and their F1 Jersey Crossbred Cows. A Case of Guduru Livestock production and Research Center and Its Surroundings, West Oromia, Ethiopia. *Science, Technology and Arts Research Journal*, 3(4), 79–84.

Dereje, B. Z. (2018). Evaluation of Estrous Synchronization and Mass Artificial Insemination Service of Dairy Cattle in East Wollega Selected Districts, Western Ethiopia. *Journal of Reproduction and Infertility*, 9(3), 63–66.

Desalegn, G. G. (2008). *Assessment of Problems/Constraints Associated with Artificial Insemination Service in Ethiopia.* MSc. Thesis, Addis Ababa University, Ethiopia.

Desta, K. B. (2002). *Analyses of Dairy Cattle Breeding Practices in Selected Areas of Ethiopia*. PhD Thesis, Humboldt-Universität zu Berlin, Germany, 37, 247–252.

Diskin, M. G. & Sreenan, J. M. (2000). Expression and detection of estrus in cattle. *Reproduction Nutrition Development*, 40, 481–491.

Emebet, M. & Zeleke, M. (2014). Reproductive performance of crossbred dairy cows in eastern lowlands of Ethiopia. *Livestock Research for Rural Development*, 19(11), Article Number 161.

Engidawork, B. (2018). Artificial Insemination Service Efficiency and Constraints of Artificial Insemination Service in Selected Districts of Harari National Regional State, Ethiopia. *Open Journal of Animal Sciences*, 8, 239–251. https://doi.org/10.4236/ojas.2018.83018.

Ermed, H. (2004). *Evaluation of reproductive performance of F1 Friesian x Zebu crosses under small holder production systems in urban and peri-urban areas of North Gondar, Ethiopia.* In Abstracts of DVM Thesis (1985-2005), Addis Ababa University, Ethiopia.

Fekata, A., Galmessa, U., Fita, L., Merera, C. & Bekuma, A. (2020). Dairy cattle producers' perception on Oestrus Synchronization and mass artificial insemination services in Waliso and Ilu Districts of South West Shoa Zone of Oromia, Ethiopia. *Insights in Veterinary Science*, 4, 10–13.

Gebremedhin, D. G. (2008). *Assessment of problems/constraints associated with artificial insemination service in Ethiopia.* MSc Thesis Addis Ababa University, Addis Ababa, Ethiopia, 110 p.

Foote, R. H. (2002). The history of Artificial insemination: Selected notes and notables. *Journal of Animal Science*, 80, 1–10.

Ganchou, F. P., Belloso, E. S., Stagnaro, C. G., Castillo, G. S. & Fonseca, H. (2005). Factors affecting fertility according to the postpartum period in crossbred dual-purpose suckling cows in the tropics. *Tropical Animal Health Production*, 37, 559–572.

Getabalew, M. & Alemneh, T. (2019). Status of Artificial Insemination; Its Constraints and Estrous Synchronization in Ethiopia. *SM Journal of Reproductive Healthand Infertility*, 4(1), 1008.

Gizaw, S., Tesfaye, Y., Mekuriaw, Z., Tadesse, M. Hoekstra, D., Gebremedhin, B. & Tegegne, A. (2016). *Oestrus Synchronization for Accelerated Delivery of Improved*

Dairy Genetics In Ethiopia: Results From Action Research And Development Interventions. LIVES Working Paper 12. Nairobi, Kenya: International Livestock Research Institute (ILRI).

Hafez, E. S. E. (1993). *Reproduction in Farm Animals*. 6th ed. Lea and Febiger Philadelphia, 465−468.

Haileyesus, A. (2006). *Evaluation of Artificial Insemination service efficiency and reproductive performance of F1 Friesian crosses in North Gonder Zone, Amhara Region, Ethiopia*. MSc. Thesis, Alemaya University, Ethiopia, pp. 81.

Heins, B. J., Hansen, L. B. & Seykora, A. J. (2006). Fertility and survival of pure Holstein versus crossbreds of Holstein with Normande, Montbeliarde and Scandinavian Red. *Journal of Dairy Science*, 89, 4944−4951.

Heins, B. J. (2007). Impact of an old technology on profitable dairying in the 21st Century. 4th Biennial WE Petersen Symposium, 2007.

Hunduma, D. (2012). Reproductive performance of crossbred dairy cows under smallholder condition in Ethiopia. *International Journal of Livestock Production*, 3(3), 25−28.

Islam, M. S., Akhtar, A., Hossain, M. A., Rahman, M. F. & Hossain, S. S. (2017). Reproductive Performance and Repeatability Estimation of Some Traits of Crossbred Cows in Savar Dairy Farm. *Journal of Environmental Science & Natural Resources*, 10(2), 87−94.

Kathy, L. (2004). AI bulls ranked by conception rates. *Michigan Dairy Review*, 1-3, http://www.mdr.msu.edu.

Khan, F. A., Prasad, S. & Gupta, H. P. (2013). Effect of heat stress on pregnancy rates of crossbred dairy cattle in Terai region of Uttarakhand, India. *Asian Pacific Journal of Reproduction*, 2(4), 277−279.

Kindalem, B. (2019). The problem of Artificial Insemination (Study in Janamora Wereda). *International Journal of Agriculture and Agribusiness*, 3(1), 8−14.

Kinyua, J. (2016). Evaluation of Artificial Insemination Services Performance in a Smallholder Dairy Herd under Extensive Management: A Case Study of KALRO-Lanet Herd, Kenya. *Weber Agricultural Research & Management*, 2(2), 1−3.

Kumar, N., Yemane, A., Berihu, G. & Yohannes, H. (2014). Productive and Reproductive Performance of Local Cows under Farmer's Management in and around Mekelle, Ethiopia. *IOSR Journal of Agriculture and Veterinary Science*, 7(5), 21−24.

Landiver, C., Galina, C. S., Duchateou, A. & Navarro-Frierro, R. (1985). Fertility trial in zebu cattle after a natural or controlled estrus with PGF2α: comparing natural mating with AI. *Theriogenology*, 23, 4−21.

Legesse, D. (2015). *Assessment of breeding practices and evaluation of mass estrus synchronization of dairy cattle in Sidama Zone, Southern Ethiopia*. MSc. Thesis, Hawassa University, Ethiopia.

Lobago, F., Bekana, M., Gustafsson, H. & Kindahl, H. (2007). Longitudinal observation on reproductive and lactation performances of smallholder crossbred dairy cattle in Fitche, Oromia Region, Central Ethiopia. *Tropical Animal Health and Production*, 39, 395−403.

Lohuis, M. M. (1995). Potential benefits of bovine embryo--manipulation technologies to genetic improvement programs. *Theriogenology*, 43, 51−60.

Malede, B., Zerihun, B. & Tewodros, F. (2013). Assessment on Problems Associated with Artificial Insemination Services in West Gojjam Zone, Ethiopia. *Advances in Biological Research*, 7(2), 59−66.

Mebrahtom, B. & Hailemichael, N. (2016). Comparative Evaluation on Productive and Reproductive Performance of Indigenous and Crossbred Dairy Cow Managed under Smallholder Farmers in Endamehoni District, Tigray, Ethiopia. *Journal of Biology, Agriculture and Healthcare*, 6(17), 96−100.

Menale, M., Mekuriaw, Z., Mekuriaw, G. & Taye, M. (2011). Reproductive performance of Fogera cattle at Metekel Cattle Breeding and Multiplication Ranch, North West Ethiopia. *Journal of Animal and Feed Research*, 1(3), 99−106.

Mohamed, A. (2004). *Estimation of genetic parameters of birth weight, age at first calving and milk production trait in Holstein Friesian dairy herds kept in three state farms, Ethiopia*. MSc. Thesis, Alemaya University, Ethiopia.

Mugisha, A., Kayiizi, V., Owiny, D. & Mburu, J. (2014). Breeding Services and the Factors Influencing Their Use on Smallholder Dairy Farms in Central Uganda. *Veterinary Medicine International*, Volume 2014, Article ID 169380, 6 p. http://dx.doi.org/10.1155/2014/169380.

Mukassa-Mugerwa, E., Tegegn, A. Mattoin, M. & Cecchini G. (1989). Effect of Estrus Synchronization with Prostaglandin F2α in Ethiopian Highland Zebu (*Bos indicus*) cows. *Animal Production*, 48, 367-373.

Mukhtar, M., Salman, D. & Bahua, R. (2019). Effectiveness and Performance of Artificial Insemination Service Units in Supporting Agribusiness Programs and Increasing Beef Cattle Population in Pohuwato Regency. *International Journal of Innovative Science and Research Technology*, 4(4), 103−110.

Mureda, E. & Mekuriaw, Z. (2007). Reproductive performance of crossbred dairy cows in Eastern Lowlands of Ethiopia. Agricultural College, ATVET, Holleta, Ethiopia.

Negussie, E., Brannang, E., Banjaw, K. & Rottmann, O. U. (1998). Reproductive performance of dairy cattle at Assella livestock farm, Arsi, Ethiopia. I: Indigenous cows versus their F1 crosses. *Journal of Animal Breeding and Genetics*, 115, 267−280.

Nibret, M. (2012). Study on Reproductive Performance of Crossbred Dairy Cows under Small Holder Conditions in and Around Gondar, North Western Ethiopia. *Journal of Reproduction and Infertility*, 3 (3), 38−41.

Niraj, K., Alemayehu, E., Berihu, G. & Endale, B. G. (2014). Reproductive performance of indigenous and HF crossbred dairy cows in Gondar, Ethiopia. *IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS)*, 7(1), 56−61, www.iosrjournals.org.

Niraj, K., Berihu, G., Nigus, A. & Etsay, K. (2017). Performance of Crossbred Dairy Cows under Farmers' Management in and Around Debre Zeit, Ethiopia. Ethiopian Journal of Veterinary Science and Animal Production (EJVSAP), 1(1), 66−72.

Nuraddis, I. & Ahmed, S. (2017). Review on Reproductive Performance of Crossbred Dairy Cattle in Ethiopia. *Journal of Reproduction and Infertility*, 8(3), 88−94.

Perry, G. A. (2005). *Comparison of the efficiency and accuracy of three estrous detection methods to indicate ovulation in beef cattle*. South Dakota State University Beef Report, pp. 122−127.

Potdar, V. V., Bhave, K., Gaundare, Y., Awasthi, H. R. & Khadse, J. R. (2016). Factors Influencing Conception Rate of Local and Crossbred Cows. *IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS*), 9(10), 51–54.

Rick, R. (2013). *Synchronizing Estrus in Beef Cattle*. University of Nebraska-Lincoln | Lincoln, NE 68588 | 402−472.

Riyad, J., Anwar, H., Jelalu, K. & Kiros, W. (2017). Assessment on problems associated with artificial insemination service in dairy cattle in Tullo district, West Hararghe, Ethiopia. *Ethiopian Veterinary Journal*, 21(2), 62−74.

Rodriguez-Martinez, H. (2000). Evaluation of frozen semen: Traditional and new approaches: In the topic of bull fertility. Traditional and new. Chenoweth (Ed.) *Topics in Bull Fertility: International Veterinary Information*; International Veterinary Information Service, pp. 1.

Schafer, D. W., Brinks, J. S. & Le Fever, D. G. (2007). *Increased calf weaning weight and weight via estrus synchronization*. Beef Program Report. Colorado State University, 115−124.

Schuller, L. K., Burfeind, O. & Heuwieser, W. (2014). Impact of heat stress on conception rate of dairy cows in the moderate climate considering different temperature humidity index thresholds, periods relative to breeding, and heat load indices. *Theriogenology*, 81, 1050−1057.

Seblewengel, A., Derese, D. & Wahid, M. A. (2018). Evaluating the Efficiency of Artificial Insemination Following Estrous Synchronization on Cows in Konta, Special Woreda, Southern Ethiopia. *Global Veterinaria*, 20(4), 181−187.

Sena, T., Guesh, F., Adugnaw, A., Beletech, H. & Workalem, D. (2014). Assessment of Productive and Reproductive Performances of Cross Breed Dairy cows in Debre tabor town, Ethiopia. *Journal of Biology, Agriculture and Healthcare*, 4, 23, www.iiste.org

Shankar, B., Jotan, K., Arup, S., Nijaya, M. & Sabuj, K. N. (2017). Success of estrus synchronization and artificial insemination in cattle among the NGO supported farmers at Char area in Bangladesh. *International Journal of Advanced Research in Biological Sciences*, 4(5), 166–170. DOI: http://dx.doi.org/10.22192/ijarbs.2017.04.05.018

Shiferaw, Y., Tenhagn, B. A., Bekana, M. & Kassa, T. (2003). Reproductive performance of crossbred Dairy cows in different production systems in the central Highlands of Ethiopia. *Tropical Animal Health Production*, 25, 551–561.

Sinishaw, W. (2004). *Study on semen quality and field efficiency of AI bulls kept at the National Artificial Insemination Center*. MSc. Thesis, Addis Ababa University, Ethiopia.

SPSS (2012). Statistical Package for Social Science (SPSS) software, Version 20.

Suyadi, S., Hakim, L., Wahjuningsih, S. & Nugroho, H. (2014). Reproductive Performance of Peranakan Ongole (PO)- and Limousin x PO Crossbred (Limpo) Cattle at Different Altitude Areas in East Java, Indonesia. *Journal of Applied Science and Agriculture*, 9(11), 81−85.

Tadesse, B. (2002). *Reproductive performances of zebu (Fogera) breed in the central highlands of Ethiopia*. DVM. Thesis, Addis Ababa University, Ethiopia.

Tadesse, M., Thiengtham, J., Pinyopummin, A. & Prasanpanich, S. (2010). Productive and reproductive performance of Holstein Friesian dairy cows in Ethiopia. *Livestock Research for Rural Development*, 22 (2), 21.

Tafari, Y. (2016). A study of level of reproduction of crossbred dairy cows under smallholder condition in Ethiopia. *African Journal of Dairy Farming and Milk Production*, 3(3), 149−151.

Teddy, M. W. (2017). Hormonal response rate, conception rate and calving rate of cows and heifers in South West Ethiopia. *Global Journal of Animal Science, Livestock Production and Animal Breeding*, 6 (3), 486–489.

Tesfa, G. (2009). *Reproductive performance of indigenous dairy cattle in south Wollo*. MSc. Thesis, Mekelle University, Ethiopia. 65 p.

Tesfaye, A., Alemayehu, L., Tefera, Y. & Endris, A. (2015). Factors affecting the reproductive performance of smallholder dairy cows in two regions of Ethiopia. *Livestock Research and Rural Development*, 27(3), 46. http://www.lrrd.org/lrrd27/3test27046. html.

Tesfay, B., Tsegay, G., Haftu, K., Teferi, A. & Bereket, H. (eds.) (2019). *Participatory Agricultural Production Constraints Appraisal: Implication for Research and Development Interventions in Southern, North Western and Western Zones of Tigray*. Tigray Agricultural Research Institute and Agricultural Growth Program-II, Proceedings of the Workshop, 09-15 November 2018, Tigray, Ethiopia.

Tegegn, F. & Zelalem, A. (2017). Evaluation of oestrus synchronization and mass artificial insemination service of dairy cattle in Mizan Aman area, Bench Maji zone, South West Ethiopia. *International Journal of Livestock Production*, 8(1), 1–4. DOI: 10.5897/IJLP2016.0338

Todd, R. (2012). Strategies to improve reproduction during summer, http://www.extension.org/pages/62993/strategies-to-improve-reproduction-during-summer.

Van Pelt, M. L. (2016). Changes in the genetic level and the effects of age at first calving and milk production on survival during the first lactation over the last 25 years. *Animal*, 2016, 1–8.

Vishwanath, R. (2003). Artificial insemination: the state of the art. *Theriogenolog*y, 59, 571–584.

Yifat, D., Kelay, B., Bekana, M., Lobago, F., Gustafsson, H. & Kindahl, H. (2009). Study on reproductive performance of crossbred dairy cattle under smallholder conditions in and around Zeway, Ethiopia. *Livestock Research for Rural Development*, 21(6).

Shiferaw Y., Tenhagen, B. A., Bekana, M. & Kasa, T. (2003). Reproductive performance of cross bred dairy cows in different production systems in the central highlands of Ethiopia. *Tropical Animal Health Production*, 25, 551–561.