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Evaluating the Efficiency of Artificial Insemination Supported by Estrus Synchronization of Dairy Cows in East Gojjam Zone, Ethiopia

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Abstract The study was conducted to assess the breeding practices of dairy cattle in the Dejene and Machakel districts. In the study, the effectiveness of prostaglandin hormone was evaluated, and different factors that affected pregnancy in synchronized cows were detected. Among cows treated with prostaglandin, 54% of them were responded positively. There was a significant difference between breeds in responded cows, and local cows were greater than the crossed-responded cows. The estrus rate was estimated to be 61.11% and 46.66%in Dejene and Machakel districts for prostaglandin injection, respectively. There were significant differences between Artificial Insemination Technicians (AITS) on estrus rate. The conception rates for the injection of prostaglandin were 39 % and 14% in Dejene and Machekel districts, whereas the number of services per conception were 1.56 and 2.55 in Dejene and Machakel, respectively. The overall conception rate and number of services per conception for prostaglandin injection were 28.5% and 2.20, respectively. Improvements in facilities and management should be necessary before implementing effective estrous synchronization. The artificial insemination technicians (AITS) must update recent skills and knowledge. Finally, the information on breeding practice assessment and evaluation of the effectiveness of prostaglandin injection may serve as a basis for improving the fertility of dairy cows, which in turn will help in designing appropriate breeding strategies for dairy cattle.

Keywords Artificial Insemination, Estrus, Synchronization, Dairy Cows

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1. Introduction

Ethiopia has the largest livestock population in Africa, with 65 million cattle, 40 million sheep, 51 million goats, 8 million camels, and 49 million chickens. According to (CSA, 2020), 98.58 percent of Ethiopia's cattle have been reported to be indigenous breeds that are poor in major economically important traits. Consequently, productive and reproductive performance of dairy cattle has remained low. The use of artificial insemination in Ethiopia is growing, but estrus detection is difficult owing to the poorly expressed estrus of Zebu breeds (Murugavel et al., 2003). One of the most effective ways to improve both reproductive performance and genetic performance is by utilizing superior species through artificial insemination combined with estrous synchronization(Tadesse et al., 2011).

Estrus synchronization is the process of manipulating the estrus cycle, which results in standing estrus (heat) in the majority of animals in a short time. It is very effective to increase the number of animals bred during a particular breeding season. The primary goal of any estrous synchronization protocol is to induce a compact estrous response so that cattle can be inseminated at a predetermined time period with acceptable fertility(Noseir, 2003).

In order to shed light on these issues, it is very important to carry out a comprehensive study with a systematic and detailed collection of information regarding the framer's management condition. Animal performance and application of the AI technique, estrus synchronization, and signs of heat expression are paramount to enabling the identification of AI, estrus synchronization efficiency, and limiting factors of AI service efficiency in smallholder farmers. Therefore, based on this problem, the objective is to evaluate the efficiency of estrus synchronization on the reproductive performance of dairy cows under farmer's management conditions.

2. Materials and Methods

2.1 Description of Study Area

The study was conducted in the two districts of the East Gojam Zone (Dejene and Machakel). It is 298 km from Addis Ababa and 265 km from the capital city, Bahir Dar. The farming system practiced in the study area is a mixed crop-livestock production system.

2.2 Estrus Synchronization of Cows

2.2.1 Materials and chemical

The material used during estrus synchronization were animal handling crash, cut/scissor, Prostaglandin (Lutalyse), Long sleeved gloves; Latex hand gloves, Needles, Drenching Gun, Syringes (5-10 ml), Sheath, Ear tag Applicator, Ear tags marker alcohol, savlon and animals.

2.3 Sampling for estrus synchronization

The experiments were conducted on-farm dairy cows from rural farms in two districts of East Gojjam, Amhara National Regional State, Ethiopia. 180 cows (90 cows from each district) were selected that fulfilled the preconditions for estrus synchronization with different parties and were greater than 60 days post-partum. All animals were evaluated for BCS (body condition scoring) and examined for general health, performance, and abnormalities of reproductive tracts to confirm the reproductive stage, the presence of mature corpus luteum, and whether they were free from any reproductive tract abnormalities and pregnancy tests prior to hormone administration by rectal palpation.

The body conditions of the cows selected ranged from 2 to 4 on a scale from 1 to 5. Body condition: 1 for thin, 2 for moderate, 3 for optimal, and 4 for fat. A rectal palpation examination was performed to confirm cows with a functional corpus luteum (CL). Non-pregnant heifers or cows were selected from the population purposefully based on CL presence, body condition, and health from any sign of disease. All selected cows (180) were given an intramuscular injection of PGF2α (Postaglandin) (33.5 mg of dinoprost tromethamine per 5 mL of solution, equivalent to 25 mg of PGF2α; Lutalyse®; Bahir Dar Ethiopia) on day zero.

The cows that exhibited mucus discharge, mounting, and bellowing together were considered to have an open estrus response, while those that did not show signs of the estrus having loosened the cervical opening through rectal palpation were assumed to have a silent heat response. Dairy cows were based on signs of heat and were inseminated immediately after the cows that came into heat were reported by AIT's (Artificial Insemination

Technicians). Rectal palpation was done 70 to 90 days after AI for both cows. In general, the number of services per conception was calculated by the total number of services inseminated per total number of cows conceived, and the conception rate was calculated by the total number of pregnant cows per total number of cows inseminated multiplied by 100(Khatun et al., 2014).These formulas are shown below.

2.4 Methods of Data Analysis

The data collected during the study were the body condition score of the animals, parity of the cow, date of hormonal administration, date of heat detection, date of insemination, time of insemination and treatment, and date of conception. All the collected data was fed to Microsoft Excel (2010). Data on estrous rate and conception rate were analyzed using frequency distribution in SPSS (Statistical Package for Social Science) version 20. A chi-square test was employed to test the effect of classification variables on estrous rate and conception rate. For the evaluation of the effect of a single-shot prostaglandin injection, the response variables were conception rate and estrous rate, while the class variables used were body condition, breed of dam, parity of cow, and AI technician efficiency, which were analyzed with descriptive statistics. The variation between groups was considered significant when the P value was less than 0.05. The result of the estrus detection time was presented in figures using Excel software. Then, to perform a comparative evaluation of the efficiency of the AI technician's heat response and pregnancy diagnosis.

The GLM (General Linear Model) for the evaluation of AI service efficiency and reproductive performance of dairy cows was as follows:

$Yijk= \mu + Ai + Dj + Pk + El + Bm + eijk$

Where: Yijk= Dependent variables pregnancy or conception rate

μ = overall mean

Ai =body condition score (i=1, 2, 3)

Dj= the effect of i^{th} district (j= 1 and 2)

Pk = the effect of j^{th} parity (j= 1, 2,3……)

El= efficeny of the l^{th} AI technician across the district

L,B=Effect of breed

eijk= random residual error

The conception rate was estimated from the proportion of pregnancies confirmed by rectal examination of the genital tract at day 90 of post-insemination among the total number of cows or heifers inseminated artificially with frozen semen at a specified period of time, according to (Arthur et al., 1982).

3. Results

3.1 Effect of Prostaglandin on Estrus Synchronization

A total of 180 local cows and Holstein Friesian crosses with good body condition were injected with 5 ml of prostaglandin intramuscularly. Within 2 to 5 days after injection, all the cows and heifers in heat or silent heat were artificially inseminated using 100% Holstein Friesian bull semen. The estrus responses under the two districts, breed, different parties, and body condition of dairy cows are presented in Table 1 below. A total of 180 cows were treated with prostaglandin hormone. From the total of prostaglandin-treated cows, 54.0% responded to heat. About 61.11% and 46.66% of cows showed open heat in Dejen and Machakel Districts, respectively. However, in Dejen District, comparatively, the highest number of cows responded to prostaglandin.

Table1. Effect of prostaglandin injection on Estrus rate for of dairy cows

Variables	Cows receiving TRT	№ of cows responded for TRT	Estrus Rate	X2	P-value
Location					
Dejen	90	55	61.11[a]	1.3	0.023

Machakel	90	42	46.66[b]		
Total	180	97	54.0		
Breed					
Crossbred	117	68	58.12[a]	1.53	0.03
Local	63	29	46.03[b]		
Total	180	97	54.0		
Parities					
1	32	19	59.34 [b]	2.35	0.05
2	94	54	57.45b		
3	44	17	39.64c		
4	10	7	70.0a		
Total	180	97	54.0		
BCS					
2	58	42	72.40a	4.62	0.04
3	75	40	53.33b		
4	47	15	31.90b		
Total	180	97	54.0		

BCS= Body Condition Score, X2=Chi-Squarevalue, P = probability.

In general, the overall estrus rate of prostaglandin injection is 54.0%. This figure was lower than the report of (Tegegne et al., 2012) from those Hawassa-Dale milk shade area (97.7%) and Adigrat-Mekelle milk shade (100%) areas. Similarly, the estrus rate was also lower than the report in (Kebede et al., 2013), which was 89.2%.

The estrus rate of injection of prostaglandin is presented in Table 1 above. The estrus rate was statistically significant between Dejen (61.11%) and Machakel Districts (46.66%).

There was significant variation in terms of the skill of technicians, with the highest degree of estrus rate, which implies that the skill and experience on palpation of the corpus luthum of cycling cows. On this matter, the artificial insemination technician in Dejen (T1) had the highest skill and experience, having 61.11%, while the insemination technician in Machakel (T2) had a lower value, having a 46.66% estrus rate. This difference can be contributed to by feed shortages, inefficient determination of corpus luthum, and management.

3.2 The factors affecting the number of services per conception and conception rate

The overall conception rate was 28.5% in this study area. The conception rate for injection of prostaglandin was 39% and 14.0% in Dejene and Machakel districts, whereas the number of services per conception was 1.56 and 2.55, respectively.

In general, the number of services per conception of prostaglandin injection in this study was 2.20. The number of services per conception is slightly lower than the report of(Gebremichael, 2015)), with a value of 2.63 in the central zone Tigray. Recent results were higher than 13.7% reported by (Kebede et al., 2013) in the Bahir Dar milk shed area, and (Alemneh et al., 2015)in Fogera woreda indicated that the average conception rate was 31.29%, respectively. (Gebremedhin, 2008) also reported that the average national conception rate in Ethiopia is 27%. The conception rate of this study was in line with the national rate of conception (27%) reported by(Gebremedhin et al., 2009), and in the research of (Fantahun & Admasu, 2017) it was reported that a conception rate of 24.69% was obtained. A successful pregnancy depends on the selection of appropriate cows at the right stage of the estrous cycle, heat detection farmers' skills., AIT skills on identification of functional CL, poor semen quality or problems in semen handling, and low performance of the inseminators' poor nutrition and management practices.

3.3 Effect of Parity

As shown in figure1below, about 20%, 16%, 4% and 2% of conception rates cows were recorded in parity 1, 2, 3 and 4 of the dams respectively.

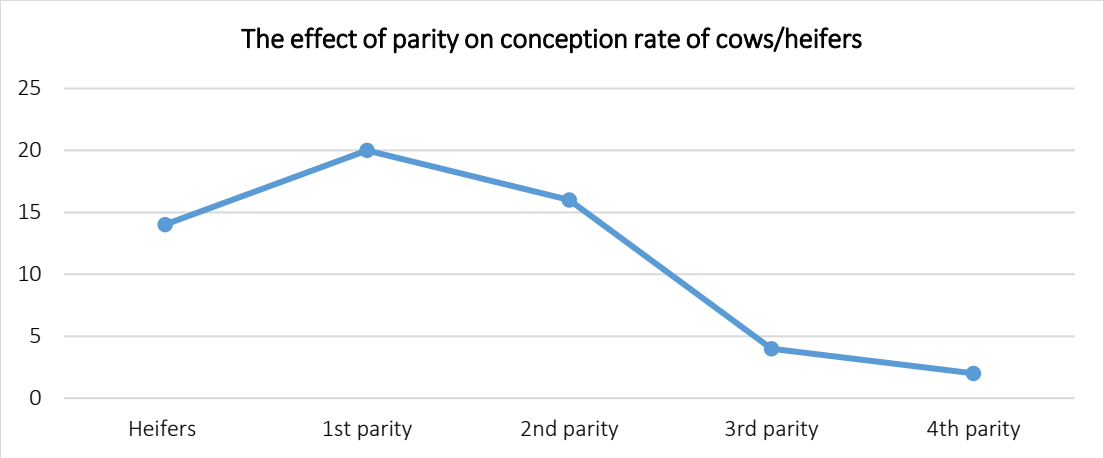

Figure 1. Effect of parity on conception rate

The parity of the breeding cows had a significant effect on the estrus rate. Among the cows, parity 1 had the highest estrus rate, followed by cows with parity 3, and then cows that gave birth to 2 were recorded, as shown in Fig. 1 above. The differences in the number of services per conception rate among cows of different parties were slight. This is in line with(Legesse, 2016) who found that the conception rate in the research was higher in the second parity. In young animals, the requirement of nutrients for continued growth and lactation places additional demand on the animal, which may influence conception. (Duro, 2022) reported that the conception rate per two, three, four, and five parities was 55.9%, 73.9, 57.1, and 44.4%, then declined at 5 to 6 parous cows, which is consistent with the finding that the pregnancy rate increased with advancing parity, starting with two to sex, then declined at parities seven and eight. The conception rate of the heifers was lower than in the other report due to factors such as time of insemination, skill of the technician, and heat detection.

He reported that the cows aged 3-5 years and 6–8 years had high CR. The lower conception rate for cows older than 8 years is because of poor body condition, inefficient nutrient utilization, and inadequate hormonal secretion, which leads to a decline in fertility.

3.4 Effect of body condition score

The BCS were significant ($P<0.05$) on conception rate as shown below.

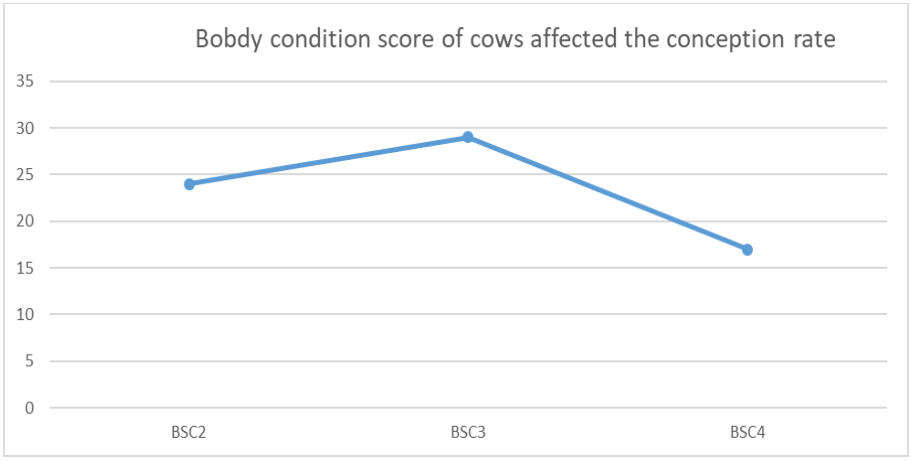

Figure 2. Effect of body condition on conception rate

The Body Condition Score had a significant (P<0.05) effect on the conception rate at first service, as shown in figure2 above. Slight differences were observed in the number of services per conception rate of cows of different body conditions. In contrast, cows with body condition scores of 2 and 3 had the greatest rate of service per conception compared to cows with a body condition score of 4. The lowest rate of conception was recorded for cattle with a body condition score of 4, as shown in figure 2above. This is in line with the report of (Gebrehiwot et al., 2015), which stated that a greater difference was observed in the oestrus rate of cows of different body conditions. In contrast, cattle with a body condition score of 5 have the lowest rate of conception (17.4%) compared to others. The cows and heifers with body conditions of 3 and 4 result in conception rates of 25% and 36.9%, respectively. Consistent with the theoretical fact, the least rate of pregnancy was recorded for cattle with the least body condition score. (Chanyalew et al., 2018) reported that the estrus response and conception rate performance can also be influenced by body condition; therefore, higher pregnancy was recorded for body condition 3, and the least pregnancy was recorded for 2 and 4 body-conditioned animals. The performance of oestrus synchronization and artificial insemination could also be influenced by the body condition of cows selected for hormone treatment. The cows with two body condition scores recorded the highest oestrus rate, followed by cows with three BCS, and those with less were those with a body condition score of four (Tara, 2018). Poor nutrition is the main cause of infertility in cattle breeding in the tropics (Bó et al., 2003).

3.5 Skill of Artificial insemination technicians

The artificial insemination technician in Dejen district (T1) had the highest skill and experience, with the lowest number of services per conception (1.56), compared to Machakel district.

Table 2. Effect of district, breed, parity, body condition and AITS for conception rate and NSC of experimental study

Variables	N	PPT	NPT	CR	NSC	X2	P-value
Location							
Dejene	55	14	41	39	1.56	4.30	0.012
Machakel	42	6	36	14.0	2.55		
Overall	**97**	**20**	**77**	**28.5**	**2.20**		
Breed							
Cross	68	30	38	44.0	1.76	1.19	0.028
Local	29	5	24	15.0	2.78		
Overall	**97**	**35**	**72**	**28.5**	**2.20**		
Parity							
1	19	7	12	37.0	2.4		
2	54	25	29	46.0	1.9		
3	17	5	12	29.0	2.3		
4	7	2	5	2.0	2.2		
Overall	**97**	**39**	**58**	**28.5**	**2.20**		
BCS							
2	42	15	17	37	2.16	1.33	0.051
3	40	12	28	29.0	2.06		
4	15	3	12	20.0	2.5		
Overall	**97**	**30**	**57**	**28.5**	**2.20**		
AITS'							
T1	55	14	41	39	1.56	15.44	0.039
T2	**42**	**6**	**36**	**14**	**2.55**		
Overall	**97**	**20**	**77**	**28.5**	**2.20**		

AITS= Artificial insemination technicians, BCS= Body condition score, PPT= Positive pregnancy test, NPT=Negative pregnancy test, CR=Conception rate, NSC= Number of services per conception, N=Number of observations

The highest number of services per conception was recorded by artificial insemination technicians in Machakel district. Similarly, there was great variation in terms of the skill of the technicians, with the highest degree of conception rate success achieved by AI technicians in Dejen District T1 (39%) and the lowest conception rate achieved by AI technicians in Machakel District T2 (14%). There was a significant difference ($P<0.05$) in conception rate due to AI technicians. The reason the conception rate might decrease is when AI is carried out by technicians with a longer duration of AI training. This implied that a longer AI training duration improved the skill of the AI technician. Insemination service is delivered as a daily round of inseminators and cellphone-based systems (Tadesse, 2010); (Gebremichael, 2015).The major problems of insemination in the tropics include technical limitation, poor heat detection, lack of transport, lack of incentives off working hours, low efficiency, and a shortage of AI technicians (Tegegne et al., 2012);(Birhanemeskel, 2014); (Gizaw et al., 2016); (Gizaw & Dima, 2016), 2016; (Legesse, 2016). There was great variation in terms of the skill of AI technicians in identifying the presence of functional corpus luteum for hormone treatment and effective AI service (Sprott & Carpenter, 2007); (Troxel, 2012).

3.6 The effect of breed

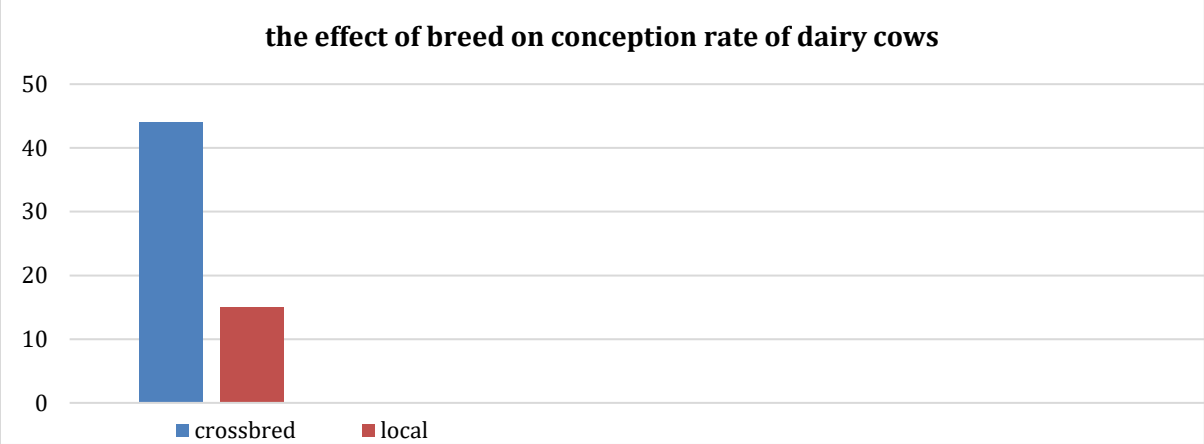

Figure 3. The proportion of the breed on conception rate

The conception rate of the indigenous cows was very low as compared to crossed cows, and the number of services per conception was lower for crossbreds. The number of services per conception rate of cross-breed cows was statistically higher than that of local breeds of cows, i.e., 1.76 and 2.78, respectively.

The first-service conception rate showed a significant ($P<0.05$) difference among crossbred (44%) and indigenous (15%) dairy cattle. A higher conception rate was observed in crossbred cattle as compared to native cattle, as shown in figure 3 above. The variation in conception among native and crossbred cattle might be due to genotype, heat detection accuracy, and farmers' bias to manage crossbred cattle better than the local cattle. The findings are similar to those of (Woldu et al., 2011), who found that farmers tend to place more emphasis on the close follow-up of their crossbred cattle than indigenous cattle.

3.7 Heat detection and time of insemination

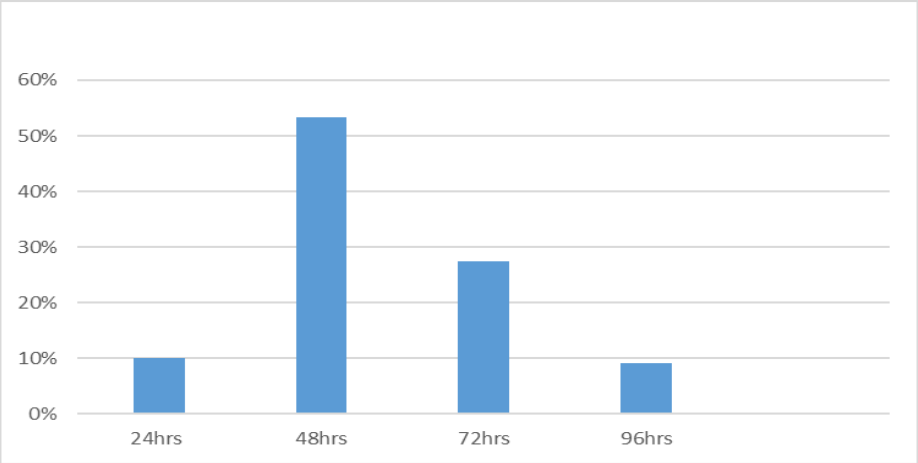

Figure 4. Time of insemination and conception rate

3.8 Time of insemination

The slightly longer means of interval between prostaglandin injection and onset of estrus was recorded in local cows than cross cows. Among cows placed under single-shot PGF2α injection, 10% of the cows manifested heat at 24 hours, 53.3% at 48 hours, 27.5% at 72 hours, and 7.5% at 96 hours. There were significant differences ($p > 0.05$) between the different time intervals of heat manifestation on the conception rate of the local and cross-breed cattle.

The conception rate of the current result was significantly ($P<0.05$) different among the times of insemination. The current finding showed that conception rates were highest when insemination was done between 48 and 72 hours (53.3%) after the onset of estrus; however, lower conception rates were observed when insemination was done before 24 hours (10%) and after 72 hours (9.5%), as shown in Fig. 4 above. The result further indicates that the conception rate decreased as the time of insemination increased.

It is greatly different from the findings of (Chanyalew et al., 2018) who reported that the highest pregnancy was achieved in animals inseminated within 7–12 hours after being detected in the estrus, and of (Jemal et al., 2016),where the highest pregnancy was achieved in animals inseminated within 10–20 hours. But it is closely similar to the findings of (Legesse, 2016), who reported >10–15 hours. While more recent experiments indicated the optimum time for AI was 4–12 hours after the onset of estrus in dairy cattle (Dorsey et al., 2011), The variation in conception among the studies could be appropriate timing of insemination, accuracy of heat detection, body condition of the animal, nutrition and management, insemination techniques, skill of the inseminator, and quality and quantity of semen. For the last seven decades, the standard for the time of insemination recognized as 12 hours after the onset of estrus (Dorsey et al., 2011) is supported by the findings of(Legesse, 2016) and (Roelofs & Van Erp-van der Kooij, 2018), which state the higher degree of conception achieved at 10–15 h of insemination after the onset of estrus. A study by (Sinishaw, 2005) also indicated that animals should inseminate within 24 hours of the onset of heat because late and early insemination may influence the CR of both heifers and cows. The variation in conception rate among different studies could be due to the inaccuracy of heat detection, time and season of insemination, and skills of the AI technician.

4. Conclusions

The estrus rate for prostaglandin injection in Dejene and Machakeldistricts were 61.11% and 46.66%, respectively. Conception rates were 28.5% and 14.0%, with a total of 28.5% and 2.20 services per conception. Estrous synchronization was high, but conception rates were low, affecting the performance of AI. Indigenous cows had lower conception rates and services per conception compared to crossbreds. The conception rate in two districts is influenced by body condition score, parity, insemination time, and AI technician skill.

Dejene district had the best rate. Successful pregnancy depends on selecting appropriate cows, responsive corpus luteum, heat detection, insemination practices, and environmental conditions.

AIT and farmers' skills are crucial for successful estrous synchronization and pregnancy. The AITS needs to update skills and knowledge, consider factors affecting estrous response, and use AI services for successful estrous synchronization. Failure to do so may result in cows and heifers dying before AI services are delivered.

List of Abbreviations	
AI	Artificial Insemination
AITs	Artificial Insemination Technicians
BCS	Body condition Score
CSA	Central Statistical Agency
CL	Corpus Luteum
GDP	Goss Domestic Product
PGF2	Prostaglandins
SPSS	Statistical Package for Social Science

Ethics approval and consent: According to the local legislation, the study involving human subjects did not require ethical permission; all data were anonymized.

***Conflicts of interest*:** The authors declare that there is no conflict of interest.

Fund statement: There is no funding for this research.

Data Availability: The data for this study is available from the author upon reasonable request.

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References

Alemneh, T., Mogess, W., Marew, G., & Adera, Z. (2015). Study on the conception rate of dairy cows artificially inseminated during natural heat and by synchronization in Fogera Woreda, North-West of Ethiopia. African Journal of Basic & Applied Sciences, 7(5), 291-297.

Arthur, G. H., Noakes, D. E., & Pearson, H. (1982). Veterinary reproduction and obstetrics. Balliere Tindall.

Birhanemeskel, A. (2014). Evaluation of the reproductive performance of crossbred (Hf X Zebu) dairy cows and artificial insemination service efficiency in and around Adigrat, North Ethiopia. North Ethiopia.

Bó, G., Baruselli, P. S., & Martínez, M. (2003). Pattern and manipulation of follicular development in Bos indicus cattle. Animal reproduction science, 78(3-4), 307-326.

Chanyalew, Y., Zewdie, T., Gatew, H., Girma, L., Kassa, G., Demis, C., Bihon, A., & Tsegaye, Y. (2018). Evaluation of two estrus synchronization protocols in dairy cattle at North Shoa zone Ethiopia. Animal Production, 19, 93.

CSA. (2020). Agricultural sample survey 2019/20 [2012 EC]. Volume II report on livestock and livestock characteristics (private peasant holdings). In: Central Statistical Agency (CSA) Addis Ababa, Ethiopia.

Dorsey, B., Kasimanickam, R., Whittier, W., Nebel, R., Wahlberg, M., & Hall, J. (2011). Effect of time from estrus to AI on pregnancy rates in estrous synchronized beef heifers. Animal reproduction science, 127(1-2), 1-6.

Duro, E. S. (2022). Cattle Breeding Practice of the Community and Evaluation of Artificial Insemination (AI) after estrus Synchronization in Wondo Genet District, Sidama National Regional State, Southern, Ethiopia. International Journal of Livestock Research, 12(9), 1-15.

Fantahun, T., & Admasu, Z. (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.

Gebrehiwot, G., Gebrekidan, B., & Weldegebriall, B. (2015). The effect of one-shot prostaglandin on estrus synchronization of local and Holstein friesian cattle in and around Wukro Kilte Awulaelo District, Northern Ethiopia. J. Biol Agricult. Healthcare, 5(7), 99-106.

Gebremedhin, D. (2008). Assessment of problems/constraints associated with artificial insemination service in Ethiopia Addis Ababa University].

Gebremedhin, D., Bekana, M., Tegegne, A., & Belihu, K. (2009). Status of artificial insemination service in Ethiopia.

Gebremichael, D. (2015). Breeding practice and estrus synchronization evaluation of dairy cattle in central Zone of Tigray, northern Ethiopia Jimma University].

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. International Livestock Research Institute.

Gizaw, T., & Dima, F. G. (2016). Journal Of Harmonized Research (JOHR). Journal Of Harmonized Research in Medical & Health Sci, 3(1), 14-37.

Jemal, H., Lemma, A., & Bekana, M. (2016). Assessment of the reproductive performance of dairy cows in smallholder dairy farms using artificial insemination. Livestock Research for Rural Development, 28(5), 2016.

Kebede, A., Zeleke, G., Ferede, Y., Abate, T., & Tegegne, A. (2013). Prostaglandin (PGF2 α) based oestrous synchronization in postpartum local cows and heifers in Bahir Dar milkshed. International Journal of Pharma Medicine and Biological Sciences, 2, 37.

Khatun, M., Bari, F., Alam, M. S., Ali, M., & Sarkar, P. (2014). Post AI conception rate in cattle at Rajarhat, Kurigram, Bangladesh.

Legesse, D. (2016). Assessment of breeding practice and evaluation of estrus synchronization of dairy cattle in Sidama Zone, Southern Ethiopia Hawassa University].

Murugavel, K., Yániz, J., Santolaria, P., López-Béjar, M., & López-Gatius, F. (2003). Prostaglandin based estrus synchronization in postpartum dairy cows: An Update. Journal Of Applied Research in Veterinary Medicine, 1(1), 51-65.

Noseir, W. M. (2003). Ovarian follicular activity and hormonal profile during estrous cycle in cows: the development of 2 versus 3 waves. Reproductive Biology and Endocrinology, 1, 1-6.

Roelofs, J., & Van Erp-van der Kooij, E. (2018). Estrus detection tools and their applicability in cattle: recent and perspectival situation. Animal Reproduction (AR), 12(3), 498-504.

Sinishaw, W. (2005). Study on semen quality and field efficiency of AI bulls kept at the National Artificial Insemination Center. Debre Zei, 53(2), 135-138.

Sprott, L. R., & Carpenter, B. B. (2007). Synchronizing estrus in cattle. Texas FARMER Collection.

Tadesse, A. (2010). The status and constraints of Artificial Insemination in cattle in the three selected Districts of Western Gojjam Zone of Amhara Region, Ethiopia. Bahrdar University, Bahrdar, Ethiopia.

Tadesse, M., Thiengtham, J., Pinyopummin, A., Prasanpanich, S., & Tegegne, A. (2011). Estrus performance of boran and boran× holstein friesian crossbred cattle synchronized with a protocol based on estradiol benzoate or gonadotrophin-releasing hormone. Agriculture and Natural Resources, 45(2), 221-232.

TAERA, M. A. (2018). Evaluation Of Efficiency of Estrus Synchronization and Assessment of Breeding Practice of Dairy Cattle in Jimma Zone, South Western Ethiopia.

Tegegne, A., Estifanos, E., Tera, A., & Hoekstra, D. (2012). Technological 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.

Troxel, T. (2012). Synchronization of Estrus in Cattle. University of Arkansas. Beef Reproduction Task Force.

Woldu, T., Giorgis, Y. T., & Haile, A. (2011). Factors affecting conception rate in artificially inseminated cattle under farmers' condition in Ethiopia. Journal of cell and animal biology, 5(16), 334-338.