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Evaluation of semen quality and field artificial insemination service efficiency in selected milk shades of selected districtsin west Wollega zone, Ethiopia

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Abstract

This study assessed bull semen quality and the efficiency of field artificial insemination (AI) services in Aira and Gulliso districts, West Wollega Zone, Oromia, Ethiopia. A retrospective survey involving 138 respondents was conducted using a structured questionnaire to evaluate AI service delivery and identify factors affecting reproductive performance. Laboratory analyses of frozen semen samples were performed at the National Animal Genetic Improvement Institute (NAGII), Kaliti, to assess semen quality and determine potential causes of reduced AI efficiency. The retrospective analysis showed that AI efficiency was not significantly influenced by year, although conception rate differed significantly among breeds, insemination seasons, and years ($P < 0.05$). The number of AI users and successful pregnancies increased over the study period. The major constraints affecting AI services included inadequate technician performance, conception failure, and delayed semen availability. Laboratory evaluation demonstrated that frozen semen stored at NAGII had significantly higher post-thaw motility, sperm viability, and lower morphological defects than semen obtained from district AI centers ($P < 0.005$). Semen collected from mature bulls (4–6 years) exhibited superior volume, concentration, and mass motility compared with that from younger bulls. The findings indicate that improper semen handling, transportation, and storage at district level compromise semen quality and AI efficiency. Strengthening cold-chain management and improving technician competency are essential to enhance reproductive performance and the effectiveness of AI programs.

1. Introduction

Ethiopia has approximately 12 million dairy cows that produce an average of approximately 1.48 L milk per cow per day over a lactation period of seven months (CSA 2020). Regarding breed types, the majority (97.8%) of the total cattle in the country are local breeds, whereas hybrid and exotic breeds accounted for approximately 1.91% and 0.32%, respectively (CSA 2020). Even though there are a large number of indigenous dairy cattle in Ethiopia, it is necessary to work hard to improve the productive and reproductive performance of cattle through proper selection of the most promising breeds and crossbreeding of these indigenous breeds with high producing exotic cattle has been considered as a practical solution and AI activities, as reviewed by the USDA (Zekarias, 2019; Mekonnen et al., 2010).

Artificial insemination has become one of the most important methods for improving farm animals' genetics. Artificial insemination has an ample role for the genetic improvement programs, mainly due to well-established methods for identifying males with the highest genetic merit (Leboeuf et al., 2000; Aynalem et al., 2011). At present, frozen-thawed semen is extensively used for AI in animal breeding program throughout the world (Ball and Peters, 2004).It has been widely used for dairy cattle breeding as the most important management practice available to the cattle producer, resulting in the availability of high genetic merit bulls to all (Gebre, 2005). Artificial insemination (AI) is one of the initial perfected technologies and the most commonly used valuable biotechnology has been in operation in Ethiopia. On the other hand, artificial insemination as assisted reproductive technology had been going on for nearly fifty years (Seid, A. and Aliy, M., 2017). Still small amount of Artificial Insemination (AI) used for breeding purpose and to increase the production performance of dairy cattle for the next generation low (Godadaw et al., 2015).There are many constraints including; infrastructural, managerial and financial constraints and also due to technical problems such as; poor heat detection, improper timing of insemination and embryonic death that causes the performance of dairy cattle losses (Tekalign, 2021).

At the national level conception rates to first inseminations, in general, are poor ranging from 7.14 to 40.23% (Desalegn, 2008).The main cause of inefficiency of AI service delivery system reported (Gebregiorgis *et al*., 2016; Tessema and Atnaf, 2015; Zerihun *et al.* 2013; Desalegn *et al*., 2009) is lack of the necessary inputs and equipment, unreliable supply of liquid nitrogen, poor quality of semen, lack of proper record-keeping at farm level is also be considered as an important factor affecting the country’s dairy cattle breeding and improvement in the country.

Though to ensuring the success of the AI program, regular supervision should be taken by evaluating the reproductive performance of the dairy cow under the prevailing management and environmental conditions since dairy cattle are important sources of food and income for smallholders, especially in urban and per urban areas of Ethiopia. The major

determinant factors in dairy cows' reproductive performance are herd profitability by affecting the efficiency of milk production, the number of calves produced per cow, and lifetime milk production (De Varies 2006). The success of AI is determined by conception rate and the accompanied high age at first calving ranged between 34 months and 44 months by (Hunde et al., 2015). Reproductive problems related to cross breed dairy cows under farmers' conditions are also vast (Bekele Tadesse, 2005; Alemayehu Lemma; Solomon Kebede, 2011).

According to Morrell, M.J. (2011) the semen quality is critically important for the success of AI and the most useful for AI if it can be cryo-preserved, since this method of preservation ideally enables the semen to be stored for an unlimited period and availability of genetic material from superior bulls without geographical limitations. Hence, failure to properly evaluate the semen would render the risk of passing over poor genetic material to a larger population. Further, the process of cryopreservation and later on thawing for AI are known to adversely affect the survival of the sperms even under the best technique available today (Lemma, A., 2011). The success of AI program, therefore, largely depends on the quality and fertility of semen that has been rigorously evaluated. Though there are different methods of semen evaluation but gross and microscopic evaluation only are basically employed at NAIC (Gebremedhin, D., 2008; Demeke, N., 2010).

Despite the wide application of AI services, and assessment of artificial insemination were done in different parts of Ethiopia like around Ejere district, Western Shoa (Sisay *et al.*, 2017); evaluation of the reproductive performance of crossbred (HF x Zebu) dairy cows and artificial insemination service efficiency in and around Adigrat (Alemshet, 2014), however, the success rate is still low in Ethiopia in generally (Belachew,2003; Desalegn,2008) due to semen quality, AI technical, financial (Azage *et al.*, 1995; Woldu *et al.*,2011) and West wollega particularly. Artificial insemination was practiced in west Wollega since several years and also there is good interest of farmers towards this technology. The main causes for low success rate of Artificial insemination in the study area is not well identified and no attention was given to study this problem .There was no research carried out on the evaluation of bull semen quality and field Artificial Insemination service efficiency in Aira and Gulliso Districts, West Wollega zone. Therefore, having this in mind, the main objectives of this study was on the evaluation of bull semen quality and field Artificial Insemination service efficiency in Aira and Gulliso Districts, West Wollega zone Oromia, Ethiopia.

2. Materials and methods

2.1. Description of the Study Area

The study was conducted in Oromia Regional State, West Wollega Zone of Aira and Gulliso Districts. These two districts were selected purposively for this study based on their potential for dairy production and availability of long duration in applying field artificial insemination service in the study area.

2.2. Sampling Techniques and Sample Size Determination

2.2.1. Sampling techniques

The study districts were selected purposely based on the potential of artificial insemination and milk-shade and availability of long duration in applying field artificial insemination service districts (Aira and Gulliso).From these districts, the farmers who were AI beneficiaries were selected for this study. From the AI beneficiaries the respondents were selected randomly from the individual.

2.2.2. Sample size determinations

The total sample size for the household was determined by using Cochran (1977) formula for an infinite population (infinite population ≥ 10,000**).**

$$No = \frac{Z^2\,(pq)}{e^2}$$

No=Desired sample size according to Cochran's (1977) when population greater than 10,000,

Z^2= standard normal deviation (1.96 for 95% confidence level);

P = 0.1 (proportion of population to be included in sample, i.e., 10%), where p + q=1

q = 1-0.1, that is, 0.9; e^2 = degree of accuracy desired (0.05). So, in this finding the sample size was:

$No = \frac{(1.96)^2(0.1)(0.9)}{(0.05)^2}$ = 138HH respondents

2.3. Data Collection Methods

2.3.1. Survey data

Primary data were collected from randomly selected AI beneficiaries' households using a semi-structured questionnaire by the support of Development agents (DA) on dairy cattle production systems, management practices, and reproductive (performance, efficiency and effectiveness of AI service and its constraint were collected. Also, from artificial insemination technicians who collect data on the data recording, arrival of frozen semen to the AI site, management of liquid nitrogen container and how they could top up the liquid nitrogen container, how AI technicians contact the farmers when a cow is in estrus, how they could travel to the estrus cow and how they detect the estrus status of the cow.

2.3.2. Retrospective study

In this phase study, the relevant data (like number of inseminated cows, number of pregnant cow, cow breed and insemination season) were collected from AI inseminator's record book of the two districts. Data recorded from 2016 to 2020 years were used for the study. From recorded data the amount of inseminated cow, pregnancy and calves born within these years in both districts were captured from secondary data of office of agriculture of the district. Meanwhile, only cows with complete information were identified and included in phase. From this recorded data, Number of services per conception, cow breed, and insemination season were collected.

2.3.3. Evaluation of semen quality

This was conducted at the Kality National Animal Genetic Improvement Institute (NAGII) and in the two districts of West Wollega Zone. The institute NAGII was responsible for the coordination of AI operations in the country. Duration of the research work, between April1, 2021-May 30, 2021 and 10 bulls were used for semen collection in the center. All the bulls, which was in use for semen production (n = 10) 5 from HF and 5 from Jersey at NAGII.

2.3.3.1. Data on semen quality

2.3.3.2. Semen collection and processing

Semen collection schedule was once a week on Monday for eight week of data collection. Bulls to be ejaculated went through preparatory measures including showering, drying and cleaning, brushing, grooming and half an hour exercise. The bulls were then allowed to mount a teaser bull and the semen was collected with the help of a pre-warmed (42 to 45°C) artificial vagina. Ejaculate volume was recorded directly from the graduated semen collection tube. Immediately after collection, the semen was subjected to initial examination of volume, color, concentration and motility; after which they were further processed as per the laboratory's standard procedure. The minimum initial standards of the laboratory were a volume of greater than or equal to 2 ml, color ranging from milky white to creamy, concentration of greater than or equal to 500 million/ml and an initial motility of above or equal to 70%. Each ejaculate was examined for mass motility, individual

motility and sperm concentration and ejaculates having less than 50% sperm motility were discarded. According to this study, a total of 80 straws of fresh bull semen was collected from 40 HF and 40 Jersey at NAGII. Evaluation of fresh semen was done immediately after collection using the method described by Herman and Madden (1963). The volume, color, density, mass motility (%), sperm concentration (mi llion/ml), live sperm count (%), measurements of spermatozoa of individual bull were recorded. In brief, the straws were thawed at 37°C for 30 seconds in a water bath, and a drop of thawed semen was placed over a warm slide and covered by cover slide Stage- heated microscope with a magnification of 100 Xs for mass activity, microscope with a magnification of 200X were used for sperm motility, and 100x for morphology were used. The values for semen parameters were recorded while semen was collected. The semen parameters included are semen color, volume, mass activity, individual motility, live-dead percentage, and morphological abnormalities of the semen collected from AI bulls. Semen analysis was carried out following with the procedures provided by (Garner, 1991; Herman et al., 1994; Bearden et al., 2004).

From two districts 40straws of Frozen bull semen was collected and NAGII at kaliti to evaluate different semen quality parameters. A total of 80 straws of frozen semen from 40 Holstein and 40 Jersey 100% breed bulls from districts and NAGII were obtained and evaluated in the laboratory. Sperm motility was assessed according to the method reported by (Dahmani, 2009). The evaluation was conducted by transporting sample semen from each study area to the semen laboratory at NAGII using a container with periodically controlling and filling liquid nitrogen and by making maximum care for the semen. Semen motility were determined in a total of 80straws from 10x8 bulls, in which 40 belonged to HF and 40Jersey and 40 each at NAIC and selected Districts.

3.4. Statistical Analysis

The collected data were entered to Microsoft excel sheet and computed using descriptive statistics. The General Liner Model procedure SAS version 9.3 2014 and SPSS version 20 were used for analysis using the following models. Statistical measures that were used to summarize and categorize the research data were means, percentages and standard errors. Means were compared using LSD test.

Model: Retrospective study

$Yijkl = \mu + Bi + Dj + Sk + Eijkl$

Where: Yijk = Dependent variable (NSPC, pregnancy diagnosis)

μ = over all mean;

Bi= effect of i^{th} previous AI service year (i = 2016–2020);

Dj = effect of j^{th} season (j = dry and rainy season);

Sk= effect of k^{th} breed (k = HF and Jersey) and cow breed

Eijkl= random error.

Model II

Semen quality traits, the following model was fitted for analyses.

$Y_{ijkl} = \mu + Ai + Bj + Ck + Ml + €ijkl$

Where;

Yijk =Observed semen characteristics (semen motility, viability, morphology, volume, concentration, color)

μ = the overall mean

Ai = the effect of the i^{th} age (i = 2 ≥ to < 4, 4 ≥ to < 6)

Bj = the effect of the j^{th} sire breed (j = 2; Holstein freesia and Jersey)

Ck = Effect of the k^{th} batch number (k = 2; 2020 and 2021),

Ml = the effect of the l^{th} location AI center (l = 2; districts (Aira and Gulliso) and

NAGII), and

€ijkl = random residual error

Ethical Considerations

Ethical Approval for Animal Studies

All procedures involving animals were conducted in accordance with relevant animal welfare guidelines and regulations. Semen samples were collected only from breeding bulls during routine artificial insemination activities by trained technicians. No invasive procedures, surgical interventions, or experimental treatments were performed. After sample collection, all bulls remained healthy and continued their normal management and semen production activities at the artificial insemination centers.

Ethical Approval for Human Participation

The questionnaire survey involving artificial insemination beneficiaries was conducted in accordance with relevant ethical guidelines and regulations. Permission was obtained from the appropriate local authorities before data collection. The objectives of the study were explained to all participants, informed consent was obtained prior to interviews, participation was voluntary, and all collected information was kept confidential and used only for research purposes

3. Results and discussions

3.1. Assessment of Artificial Insemination efficiency in selected milk shades

3.1.1. Retrospective evaluation of AI efficiency

The result from retrospective listed in (Table 1). **A**ccording to this study the effect of year was not significant different on efficiency of artificial insemination. However, the mean percentage of efficiency of artificial insemination were 50.41 and 52.01 in 2016-2017 for local cows and 62.73, 65.52 and 67.79 respectively for year 2018-2020 during retrospective study. This indicated that the efficiency of artificial insemination was high in crossbreed animal than in local cow in the study area. The current study, indicated that there was significant different was observed on the conception rate of the inseminated cow between cow-bred, inseminated season as well as inseminated year/ year. The interaction of Cow-bred and Inseminated season and Inseminated season were significant different. This result was in line with national AI efficiency (CAS. 2011).; Ashebir *et al*. (2016) who reported that in Tigray regional state out of the 51032 animals inseminated 28972 animals were pregnant which around 56% is and the calves born were 18852 (37%). However, this result was disagree with Tekalign (2021) who reported that overall Efficiency of artificial insemination in this study was 59.05% in Essera Woreda, Dawuro Zone; South Ethiopia. This may be due to conception failure, shortage of semen and liquid nitrogen, heat detection problem, shortage of AI technicians, interruption of weekends and holiday's service, travel long distance to get the service. In this study the number of inseminated animals were increased with increased conception rate. These may be due to management, good awarerancy of the farmers and availability of better quality feed and water. This result was similar with Tadesse *et al.* (2022) who reported that 60.12 and 59.89 pregnancy diagnosis positive in Dessie town, Dessie zuria and Kutaber districts.

Table 1: Factor that affect in efficiency of AI during retrospective data collection in five years from AIT in the districts

Parameters		N	Efficiecy		Std. Error	P-value	C-bred* Insemseason	C-bred * AI Insem year	Insemseason * AI Inse year	C-bred* Insemseason * AI Insemiyear
			1	2						
Year effect	2016	488	50.41		2.93[a]	.990				
	2017	548	52.01		2.93[a]	.990				
	2018	609		62.73	2.86[b]	.001				
	2019	783		65.52	2.718[c]	.000				
	2020	888		67.79	2.67[d]	.000				
	P-value		NS	NS			.203	.001	.203	.036
Season effect	1	930	61.61	61.20	2.226[a]	NS				
	2	866	61.20	61.61	2.226[a]	NS				
	3	736		64.29	2.85[b]	NS				
	4	784	57.20		2.325[c]	NS				
	P-value		NS	NS						

C-bred= Cow-bred

3.2. Problem and the major constraints for efficiency of artificial insemination

3.2.1. Problems associated with efficiency of AI among users

The survey result indicted that the problems associated with efficiency of AI among users in the study area is presented on (Table 2). According to the current study the farmers of study area were challenged with many problems associated AI service which was indicated by users of AI service. From these problems conception failure, Shortage of AIT, Shortage of input, Long distance and other problem were ranked 1st ,2nd ,3rd ,4th and 5th with index values 0.27,0.22,0.21,0.18 and 0.12 respectively. Conception failure as very serious problem at the first level with index value 0.27 ranked by farmers which was associated with semen quality, inappropriate time of heat detection and insemination, cow fertility, body condition. This result was agree with Temesgen K. *et al*. (2021) who reported that about 51.35% problem associated with AI are conception failure in the in Central High Land of Ethiopia. Shortages of input (like liquid nitrogen, transport) were also the problem associated with AI in the study area. This result was in line with Tegegne and Dirk (2011) who reported that AI technician shortage and low capacity of technician, the impact of AI to improve dairy and meat animal genetic in rural areas is almost negligible and long distance problem was of due to limited AI station construction and obligated high cost AIT called to service supported (Temesgen K. *et al*., 2021; Gebremedhin, D. G. 2008). This finding was also in agreement was Sisay *et al.* (2017) who reported that shortage of AIT, long distance coverage by farmers, discontinuation of service on weekends and holidays as a main constraints of AI service in Ejere district.

Table 2: Problems associated with efficiency of AI among users in the study area (N=138)

Parameters		1	2	3	4	5	Sum	Index	Rank
AI service problems	Conception failure	43	31	24	18	10	299	0.27	1
	Shortage of AIT	8	40	28	12	5	245	0.22	2
	Shortage of input	25	18	32	11	2	229	0.21	3
	Long distance	18	12	15	25	3	202	0.18	4
	Other problem	3	10	8	5	12	127	0.12	5

AI=Artificial insemination, AIT=Artificial insemination Technician

3.2.2. Time of Insemination of cows showed heat estrus time

The survey result indicated that the time of insemination of cow showed heat estrus time in the study area is presented in (Table 3). According to the current finding, awareness of AI beneficiaries on time of insemination, revealed that animals showed heat at the morning were inseminated as heat sign is seen ,morning of the next day, as the technician order, and on the same day after noon were ranked 1st ,2nd ,3rd and 4th with index values 0.19,0.14,0.12 and 0.11 respectively . Likewise, when the cow/heifer showed heat at after noon time, insemination would be as heat sign is seen ,morning of the next day , as the technician ordered and on the same day after noon were ranked 1st ,2nd ,3rd and 4th with index values 0.34,0.26,0.21 and 0.19 respectively. The result was agree with Yohanis K. and Tilahun B. (2018); Sisay *et al* (2017) showed almost majority of the small holders indicated animals showed heat in the afternoon and morning were inseminated as the sign is seen, respectively.

Table 3: Insemination time in the study area (N=138).

Time of insemination	When cows showed heat in its													
	Morning						After noon							
	1	2	3	4	Sum	Index	1	2	3	4	sum	Index	Index	Rank
As heat sign is seen	33	24	20	6	165	0.19	30	22	16	4	138	0.16	0.34	1
On morning of the next day	8	28	15	4	125	0.14	8	25	12	2	102	0.12	0.26	2
As technical ordered	10	12	22	2	108	0.12	5	11	18	0	81	0.09	0.21	3
On the same day after noon	2	10	8	12	94	0.11	3	7	5	10	72	0.08	0.19	4

3.2.3. Major constraints of AI efficiency

The survey data indicated that the major problem of AI service of the study area is presented in (Table 4). According to the current finding shortage of semen and liquid nitrogen, AIT problem, heat detection problem, conception failure, interruption of weekends and holidays service and travel long distance to get the service with index values (0.26, 0.19, 0.16, 0.14, 0.13 and 0.12) respectively. This is similar with findings of Tekalign (2021) who reported that the Conception failure, Shortage of Semen and liquid Nitrogen, Heat detection problem, Shortage of AI technicians, Interruption of weekends and holiday's service, Travel long distance to get the service are ranked as among the major constraints of AI service in Essera Woreda, Dawuro Zone. Similarly, more than half of the respondents (95(52.5%)) are unsatisfied with the overall AI service due to different problem including, semen and liquid nitrogen doesn't come on time (54(29. %)), AIT problem (19(10.5)), heat

detection problem (16(8.8%)), conception failure (57(31.5%)), insufficiency support from concerned body (35(19.3) reported by (Yohanis and Tilahun, 2018).

Table 4: Major constraints AI service in the study area (N=138)

Constraints	1	2	3	4	5	6	sum	Index	Rank
Shortage of Semen and Liquid nitrogen	55	36	24	18	10	7	363	0.26	1
AIT problem	10	45	28	12	5	2	269	0.19	2
Heat detection problem	22	18	35	11	2	0	217	0.16	3
Conception failure	11	14	15	24	3	0	195	0.14	4
Interruption of weekends and holidays service	7	10	8	5	20	1	177	0.13	5
Travel long distance to get the service	6	8	5	2	4	16	161	0.12	6

3.3. Evaluation of semen Quality

3.3.1. Individual progressive fresh and frozen semen motility

The mean frozen and fresh semen motility in the NAGII center as well as at district is described in (Table 5). According to this study the mean frozen and fresh semen motility were 51.07±.50, 48.18±.36 and 79.35±.28, 79.15±.39 for HF and Jersey breed from the NAGII and District, respectively. This may be due to the effect of transportation, handling and environmental factors (bad weather conditions) that resulted to in decline of motility of semen at district level. However, frozen sperm individual progressive motility was measured both at national artificial insemination center (NAIC) at the end of semen processing procedures and at the regional AI service center after transportation. This result was similar with the report of in Gebremedhin, *et al. (*2009) in Debre Zeit 73.97and 75.60 for HF and Jersey respectively. Reda *et al*. (2020) also reported that the mean semen motility for both HF cross and Jersey in South Wollo Zone, Ethiopia 51.56 ± 1.58 and 43.69 ± 1.75 respectively. From this study motility of fresh semen and motility of frozen semen in the center was greater than in the districts. This difference might be attributed to differences in semen handling and storage practices, transportation from the NAGII where the spermatozoa was exposed to different environmental stresses. This result was in agreement with the study in Adigrat and Regional AI Centre(Alemshet B., 2014).The effect breed on frozen semen motility was significant (P□0.05) different.

Table 5: Individual progressive frozen and fresh semen motility (Mean ±SE)

Variables	N	Frozen semen Motility (%		Fresh semen motility	
	80		P-value	At NAGII	
Effect of Districts					
	40	41.78±.26	NS		
	40	41.03±.20			
Effect of breed					
HF	40	51.07±.50	<.0001	79.35±.28	NS
Jersey	40	48.18±.36		79.15±.39	
Effect of Batch					
B1	40	49.68±.525	NS		
B2	40	49.58±.464			

NAGII =National Animal Genetic improvement institute

3.3.2. Morphological defect

The current study indicated that the morphological defect of frozen semen of the study area is presented in (Table 6). According to this study the highest mean proportion of major defects observed in districts was 3.50±.075 which is less than Amare *et al*.(2012) and Gebremedhin, D. (2008) how reported 4.3±0.76 and 6.5± 3.08 respectively. However, in the study the mean of major defect was in line with the recommended level 4% (IAEA and FAO, 2005). The result observed in the current study indicated that there were significant (P□0.05) different between NAGII and district with mean value 2.53±.14and 3.51±.08.This high major morphological defect in the district shown that the decrement of fertility of semen. The high major morphological defects affect the AI delivery system through decreasing fertilizing ability of the post-thawed semen and by increasing the numbers of service per conception (IAEA and FAO, 2005). The differences in morphological defects between districts might be due to differences in semen handling, freezing and storage practices at different district AI service centers, and/or semen handling during transportations from NAGII to district AI service centers.

The mean minor morphological defect in this study was 8.94±2.72 and 5.43±2.75 respectively in the district and NAGII presented in (Table 6). This indicated that the minor morphological defect is high in district than in NAGII with significant (P<0.05) different. In addition, the effect of breed on minor morphological significant (P<0.05) different with mean value of 5.44±.76 and 10.92±.75 respectively. This result was dis agree with Amare *et al.* (2012) who reported the overall mean minor morphological defects of Jersey breed frozen semen (21.95± 0.86) has lower than Holstein Frisian breed (52.092± 9.85).The mean live cell and dead cell of the semen recorded in both districts and NAGII of the study area were significant (P<0.05) different with mean value 24±1.0; 33.02±.54 and 16±1.0; 6.99±.54 respectively. This may be due to chilling, freezing and storage at different AI sub center and transportation of semen from region AI sub centers to district AIC and to Kebeles sub center caused further loss of viability. When the semen was dead, the membrane was damaged and it was permeable to eosin. Between districts and NAGII both Holstein Friesian and Jersey breeds of frozen semen sample were different in live-dead percentage in this study. This result was similar with result that reported by Amare *et al* (2012). Similarly, for normal production function at least 50% of the post-thawed spermatozoa should be live, because each straw initially pack with 30 million spermatozoa and at least half of this figure should be live or 15 million sperm cells per straw expected to be live (IAEA and FAO, 2005). Even though the live-dead post thawed spermatozoa may not as such affect the AI efficiency in the study area, large numbers of spermatozoa was damaged and need great attention (Amare *et al.,* 2012).

Table 6: The major and Minor defect and dead and live percentage of frozen semen in NAGII center and Aira and Gulliso districts, west Wollega

Parameters	N	Major defect	Minor defect	Live cell count	Dead cell count
Effect of place					
District	80	3.51±.08	8.94±2.72	24±1.0	16±1.0
NAGII	80	2.53±.14	5.43±2.75	33.02±.54	6.99±.54
Overall	160	3.02±.17	7.18±2.74	28.51±.77	11.50±.77
P-Value		*	*	*	*
Effect of breed					
HF	40	2.62±.950	5.44±.76	29.28±3.28	10.73±4.27
Jersey	40	2.41±1.015	10.92±.750	27.74±3.74	12.27±4.73
Overall	80	2.51±.571	8.18±1.641	28.51±2.64	11.50±2.6
P-Value		**NS**	**NS**	**NS**	**NS**

3.3.4. The Effect of Breed and Bull Age on semen Quality

According to this laboratory result the mean Libido of HF and Jersey breed was 2.95±.04 and 2.92±.03, respectively with overall 2.94±.02 (Table 7 and Fig 2). However, the effect of breed and age of the animal was not significant (P> 0.05).Regarding volume of the semen during this experiment was significant (P< 0.05) different between breed and age of the animals with the mean value 7.18±.24, 6.24±.22 and 6.01±.16; 7.75±.26 respectively. Additionally, high semen volume and high concentration of semen recorded from matured bull (4> to <6) age. While the lower age provided lower semen volume and concentration of semen in the study area. This result was similar with Weeb (2003); Seyoum *et al*.(2021) who reported that the age are significantly affect the major semen quality measures like ejaculate volume, concentration, mass activity, individual motilities of all stages of production and production doses/ejaculate. Better semen quality in mature bulls compared to younger and older bulls may probably be due to scrotal circumference and the heat regulation mechanisms, which increases with age until the rate of broken down for testicular tissues become faster than being replaced (King, 1993; Brito *et al.,* 2008). Moreover, effect of age is also influenced by management conditions. Alemayehu and Tena (2015) reported similar result that is the smallest breeds produced the smallest semen volume while Friesian bulls gave the largest volume of semen. Bearden *et al, (*200) also reported similar result that the Young bulls and those of small sized within the species produce smaller volume of semen. Additionally, there are another factors that affect the volume and concentration of semen are ejaculate Margo, L. (2001) and breed, nutritional status, geographic locations, seasons of year, method of semen collection and handling of bulls during collection *(*Bearden *et al.,* 2000).

According to Table 7 of this study the overall mean major and minor morphological defect of bull semen of Holstein freesia and Jersey breed was 1.95±.09 and 7.42±.37of the sperm cells which was significant(P<0.05) different. This indicated that breed affect the major and minor morphological defect of bull semen. The result was in agreement with Alemu *et a l.(*2014) who reported that the highest total morphological defects were observed in 50% cross bulls (HF x Borana; 16.9%) followed by 75% cross bulls (HF x Borana; 4.6%), Friesian bulls (3.8%) and local Borana bulls (3.9%).Therefore, the report indicated that major morphological defects can influence the artificial insemination delivery system by minimizing the fertilizing capacity of frozen-thawed bull semen and enhancing the number of services per conception.

Table 7: Evaluation of fresh semen parameters from production bulls (N=10x8)

	Breed				Age			
Parameters	HF	JRS	Overall	P-value	2≥ to <4	4≥ to <6	Overall	P-value
Libido	2.95±.04	2.92±.03	2.94±.02	0.65	2.92±.040	2.97±.031	2.94±.03	0.35
Volume	7.18±.24	6.24±.22	6.71±.17	0.0006	6.01±.16	7.75±.26	6.71±.17	<.0001
Concentration	.95±.04	1.00±.03	.98±.02	0.36	.92±.04	1.05±.04	.98±.02	0.0092
Mass motility	2.60±.08	2.65±.07	2.63±.05	0.65	2.56±.07	2.72±.08	2.63±.05	0.16
PH	6.52±.07	6.35±.06	6.44±.05	0.12	6.41±.06	6.49±.09	6.44±.05	0.92
Major defect	2.48±.11	1.42±.08	1.95±.09	<.0001	2.02±.12	1.85±.13	1.95±.09	0.45
Minor defect	4.68±.26	10.17±.33	7.42±.37	<.0001	7.33±.48	7.57±.59	7.42±.37	0.58
Live cell count	80.23±.60	80.13±.48	80.18±.38	0.89	80.25±.52	80.06±.56	80.18±.38	0.81
Dead cell count	19.78±.61	19.87±.48	19.83±.38	0.59	19.75±.52	19.94±.56	19.83±.38	0.52

HF =Holstein Frisian, JRS=Jersey

3.3.4. The correlation between ***different semen parameters at district and National Animal Genetic Improvement institute (NAGII)***

The correlation of different semen parameters at district and National Animal Genetic Improvement institute (NAGII)presented in Table (8)**.** According to this study the correlation of frozen semen at district and NAGII were significant different. From this study majority of semen parameters at district and National Animal Genetic Improvement institute (NAGII) were negatively correlation (r=0.17- 0.75) with significant different.

Table 8: The correlations between different semen parameters at district and *NAGII*

	Fsm	Md	Md	Lcc	Dcc
Fsm					
Md	0.86***				
Md	-0.39***	-0.20***			
Lcc	0.46***	-0.17***	-0.26***		
Dcc	-0.75***	0.21***	0.25***	-0.62***	

*Fsm=Frozen semen motility; Md =Major defect; md=Minor defect; lcc= live cell-count; dcc =dead cell count;*** strongly correlated*

3.4.5. Proportions of HF and jersey semen colors at NAGII

With regard to the color of Holstein Friesian and Jersey breed semen, most of the collected semen had milky, creamy color and Watery (58.6%, 33.1%, and 8.3%) and (66.4%, 3% and 0.4) respectively at NAGII is presented in (Table 9). This result was in line with Dessalegn (2008) who reported that about 41.17% and 37.25% was milky and creamy respectively and Jemberu *et al.* (2014) also indicated similar result that the majority of semen samples (60%) are milky in color Kality National Artificial Insemination Center, Addis Ababa, Ethiopia. The percentage of milky and creamy colors does not differ much from the findings of Sinishaw (2005). The normal color of bull semen ranges from thick whitish to slightly yellowish fluid whose

consistency is mainly determined by the number of spermatozoa it contains (Herman *et al.,* 1994).Semen color may be affected by the type of feed and is further influenced by the subjective nature of color determination technique.

Table 9: **Proportions of HF and jersey semen colors at NAGII**

Evaluation parameters	Semen color type (%)		
Breed	Creamy	Milky	Watery
HF(40)	33.1	58.6	8.3
Jersey (40)	33.2	66.4	0.4
Age			
2≥ to <4	32.9	57.8	9.3
4≥ to <6	32.3	65.1	3.6

4. Conclusion

This study provides a broad evaluation of bull semen quality and field artificial insemination (AI) service efficiency in Aira and Gulliso districts of western Ethiopia by integrating retrospective field data with laboratory-based semen quality assessments. Although AI efficiency showed no significant variation across years, conception rate was significantly influenced by breed, insemination season, and their interaction, indicating that both biological and management-related factors contribute to reproductive performance. The increasing adoption of AI and the corresponding rise in confirmed pregnancies demonstrate the growing importance of AI as a genetic improvement strategy in the study area.

Laboratory analyses showed that semen quality was strongly associated with bull age, with mature bulls (4–6 years) producing semen of superior volume, concentration, and motility compared with younger bulls. Moreover, frozen semen obtained from district AI centers exhibited significantly lower post-thaw motility and viability and higher morphological defects than semen maintained at the National Animal Genetic Improvement Institute, indicating deterioration during transportation, storage, and field handling. These findings identify weaknesses in the semen distribution chain as a major constraint to AI success under field conditions.

Overall, the results demonstrate that improving AI efficiency requires a comprehensive approach encompassing high-quality semen production, maintenance of an effective cold chain, standardized semen handling procedures, and enhanced technical competency of AI personnel. Strengthening these components will improve conception rates, increase the efficiency of national breeding programs, and accelerate genetic improvement of cattle under smallholder production systems. Future studies should quantify the relative contributions of semen quality, technician performance, cow-related factors, and environmental conditions to AI outcomes using larger datasets and longitudinal study designs.

Declarations

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest

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Author Contribution

Mr. Degefu Jabesa and Jarmana Tasisa were responsible for collecting the data used in this research and wrote the main manuscript and prepared all figures and tables presented in the paper. Dr. Kirubel Pawulos edited and All the authors have reviewed the final manuscript for publication.

Data Availability

The datasets utilized and analyzed in this study are available upon reasonable request from the corresponding author.

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Figures

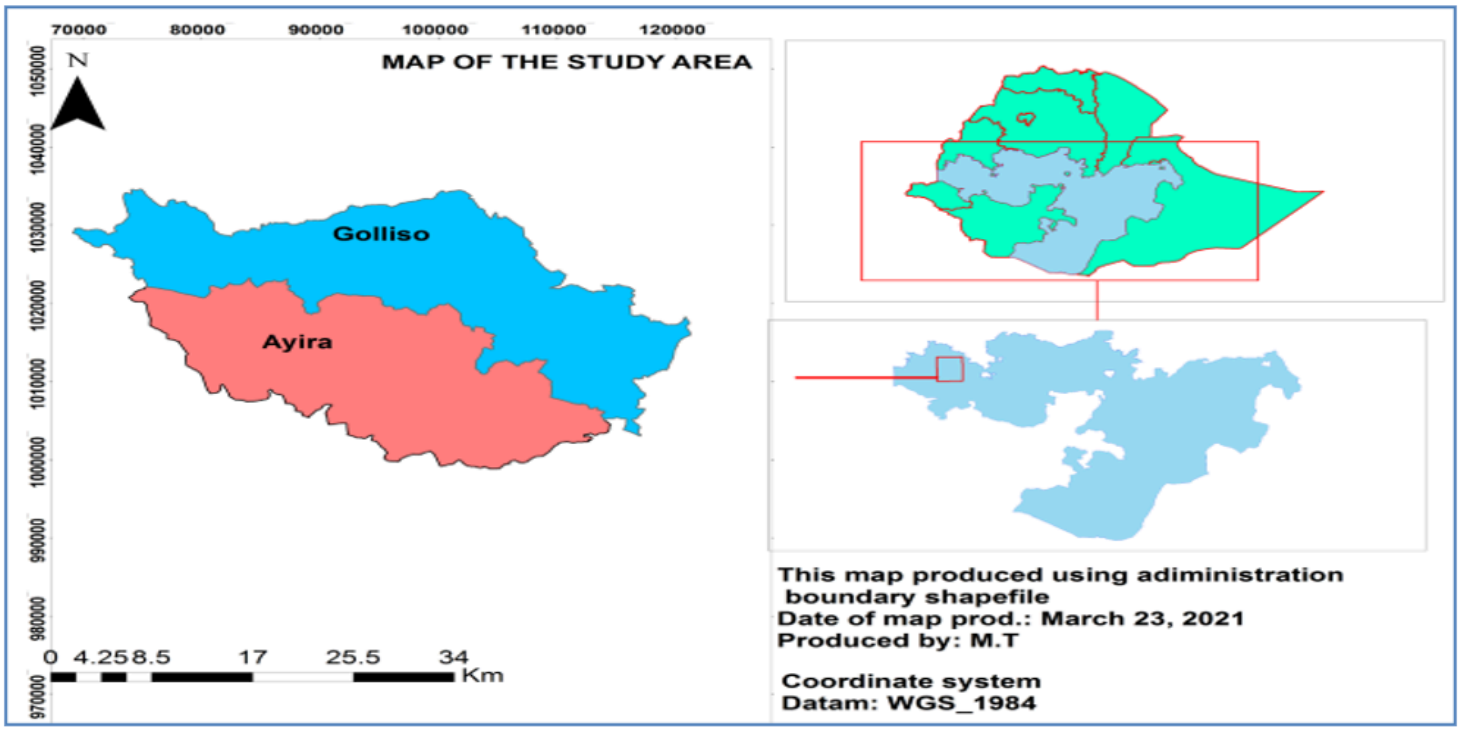

Figure 1

Map of the study area

Figure 2

Figure on semen collection and evaluation