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ANIMAL HUSBANDRY

Participatory Evaluation of Artificial Insemination (AI) Service Delivery and Semen Quality in Northern Ethiopia

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ABSTRACT

This study was conducted to assess artificial insemination service delivery system, and major constraints in urban and peri-urban areas of Adigrat, and comparison of semen quality parameters between Adigrat AI center and Tigray Region main AI center, north Ethiopia. The study involved group discussion, cross sectional survey and laboratory analysis of semen quality parameters. A total of 60 households (30 from urban and 30 from peri-urban) were selected for cross sectional survey. Sperm quality parameters were analyzed on 60 straws of frozen semen taken from Adigrat and the regional artificial insemination centers (AIC). From the survey study, 43.3 and 46.7% of urban and peri-urban AI beneficiaries, respectively, were not satisfied with the overall AIT service delivery system. About 30% of urban and 43.3% of peri-urban households indicated that, they didn't get AI service on weekend and holidays. About 26.67% and 43.3% of the participants in urban and peri-urban areas, respectively reported that, there was a shortage of AI technicians. Hence, about 63.3% and 66.7% of urban and peri-urban AI service users, respectively, switch to bull service when AI technicians were absent. From the semen quality analysis, the overall mean frozen semen motility and live sperm were 52.0±1.01 and 55.9±0.87, respectively. Semen motility and live sperm were affected ($p<0.05$) by AI centers (regional/district) but not affected ($p>0.05$) by batch number and blood level. Therefore, it was concluded that the efficiency of AI service in the study area should be improved through appropriate heat detection, improved capacity of AI technicians, awareness creation, and improved semen management practices.

Highlights

- Improved frozen semen motility and live sperm.
- Reduced satisfaction of AI beneficiaries in the overall AIT service delivery system.
- Most AI service users switch to bull service when AI technicians are absent.
- Improved frozen semen motility and live sperm.

Keywords: AI beneficiary, AI non-beneficiary, AI service, Efficiency, Semen

Artificial insemination (AI) is the first and oldest biotechnological tool used for genetic improvement of farm animals. Artificial insemination (AI) has been defined as a process by which sperm is collected from the male, processed, stored, and artificially introduced into the female reproductive tract for the purpose of conception (Webb 2003). Even though, Artificial insemination is the most commonly used and valuable biotechnology which has been in operation in Ethiopia for over 35 years, only about 1.05% of the total cattle population are hybrid and exotic breeds (CSA 2011). Cattle breeding in Ethiopia are mostly uncontrolled and making genetic improvement through Artificial insemination is a challenge. It is evident that the AI service in the country has not been successful to improve reproductive performance of dairy industry (Desalegn 2005). Recently, the government of Ethiopia and partners are making efforts to improve genetic potential of local dairy cattle through artificial insemination (AI) and thereby enhance dairy productivity in urban and peri-urban areas of the country where the demand for dairy products is high. The crossbreeding program in the country in general is running using frozen semen brought from national artificial insemination center (NAIC). But, there are limited and not well organized studies conducted to assess artificial insemination service delivery practices and its constraints and semen quality particularly in urban and peri-urban areas of Adigrat. Therefore, this research was aimed to generate relevant information on opportunities and constraints of artificial insemination service delivery and semen quality parameters in Adigrat area and Mekelle AI centre, North Ethiopia.

MATERIALS AND METHODS

Description of the Study Area

This research was conducted from January 10 up to May 30, 2016 in urban and peri-urban areas of Adigrat, and Tigray Region AI center, Tigray, Ethiopia. Adigrat is located at 14.20° North latitude and 39.29° East longitude. It is found at a distance of about 898 Km North of Addis Ababa the capital city of Ethiopia and 125 Km north of Mekelle the capital of Tigray Regional state. Adigrat town receives mean annual rainfall of 500 to 600 mm where most of it occurs from mid-June to August. The annual temperature of the town ranges from 18 to 20°C. The altitude ranges from 1500 - 2500 m.a.s.l (Alemshet *et al*. 2016).

Sampling Technique

Random and purposive sampling techniques were used to select sample AI service beneficiary households and semen straws from different blood levels, production years in both Adigrat and the regional AI centers. Adigrat area was selected purposively based on the existence of availability of long lasted artificial insemination service. For the survey study, a total of 60 artificial insemination service beneficiary households (30 from urban and 30 from peri-urban) were sampled randomly by using lottery method. A rapid reconnaissance survey was made in the study area prior to the actual data collection work. For the analysis of semen quality, 5 semen straws were sampled randomly from each blood level of the sire breed (comprising of crossbreeds (50%), high-grade (75%), and purebred (100%) of Holstein Frisian sire breed) and batch number from both Adigrat AI service center and the Regional AI center. Therefore, the total number of straws sampled was 60 (2 AI centers [Adigrat and Region] X 2 batches X 5 straws X 3 sire breeds). Semen production year (2012 and 2013) was purposely selected for analysis. Semen quality parameters (semen motility and live sperm percentage) analysis was carried out in accordance with the procedures provided by Herman *et al*. (1994) and Bearden *et al*. (2004) in the respective location to avoid transportation stress. Hence, the analysis for the regional AI center was conducted at Mekelle University, AI laboratory, College of Veterinary Medicine, whereas semen quality analysis of Adigrat AI service center was done at Adigrat University AI laboratory center.

Data Collection and Analytical Techniques

Field survey

A field survey was conducted on 60 AI beneficiary households from both production systems to collect information on major problems and constraints that influence the success of AI service and related problems in the study area. Thus, structured questionnaire was developed, pre-tested before implementation and used for the survey work (Alemshet *et al*. 2017). The questionnaire was administered by a team of enumerators recruited and trained for this purpose with close supervision of the researcher. Pertinent data was collected on efficiency and effectiveness of AI service and its constraint in the study area

Laboratory analysis of frozen semen

For the laboratory analysis, the straw was removed from the liquid nitrogen (LN_2) and was allowed to thaw in boiled water at 35-37 degree Celsius for about 30 seconds. Immediately after thawing, the straw was taken out and wiped carefully. Clean and grease free glass slide was prepared, warmed and adjusted to normal body temperature to avoid cold shock. Then, percentage of sperm individual progressive motility was subjectively assessed by placing a drop of semen on a pre-warmed slide using a light microscope under a cover slide at 400 x magnifications (scored at 10% unit intervals). For evaluation of live and dead sperm population the thawed straws were immediately broken and a drop of semen was placed on a pre-warmed slide and stained with eosin and nigrosin mixed solution. Live spermatozoa were counted under light microscope at 400 x magnification using three different counts and their average percentage was taken for analysis. Semen analysis was done based on the procedures reported by Herman *et al*. (1994) and Bearden *et al*. (2004).

Statistical Analysis

Data collected from the survey study was analysed using the descriptive statistics whereas data from the laboratory analysis was analysed using the General Linear Model procedure of SAS (SAS 2008). Means were compared using Tuky adjustment.

Model for analysis of data

Model: Semen quality parameters:

$$y_{ijkl} = \mu + a_i + b_j + c_k + e_{ijkl}$$

Where, y_{ijkl} = Observed values of semen quality (motility, viability)

μ = Overall mean: a_j = Effect of the jth sire breed blood level (j= 3; 50%, 75% and 100%): b_j = Effect of the ith location of AI center (i= 2; The Region and Adigrat AI centers): c_k = Effect of the kth batch number (k=2; 2012 and 2013) and e_{ijkl}= random residual error

RESULTS AND DISCUSSION

Characteristics of households in the study area

The characteristics of households in urban and peri- urban areas of Adigrat are presented in Table 1. The overall mean age of households in the study area was 49.5± 1.09 year. There was no significant difference (p>0.05) in age of the households between the production and breeding systems. Mean family size of the households in urban and peri- urban areas of Adigrat were 4.63±0.25 and 6.60± 0.26, respectively. The analysis of variance showed significant (p<0.05) difference in family size of the households between urban and peri-urban production systems. Higher family size was observed in peri-urban than in urban area. This implies that the work load for dairying was high in urban as compared to peri-urban area. The average age of dairy owners in the study area was within the productive age.

Table 1: Family size and age structure of households in the study area

Variables	Family Size	Age
	Mean (±se)	**Mean (±se)**
Production systems (N=120)	*	ns
Urban (n=60)	4.63^{a} ±0.26	49.9±1.53
Peri - urban (n=60)	6.60^{b} ±0.25	49.1±1.57
Breeding system	Ns	ns
AIB (n=60)	5.57±0.29	49.9±1.61
AINB (n=60)	5.67±0.29	49.1±1.49
Over all mean (n=120)	5.62±0.2	49.5±1.09

*AIB= artificial insemination beneficiary, AINB= artificial insemination non beneficiary; *=p<0.05; ns=p>0.05: $^{a-b}$means with the different superscripts under the same column for the same parameter is significantly different.*

About 83.3% urban and 70% peri-urban AI beneficiary households were male headed and 73.35% urban and 76.7% peri-urban AI none beneficiaries, were also male headed. Male to female household ratio in Adigrat Town was higher (78.3% to 21.7%) as compared to 53.3% to 46.67% reported by Abadi *et al*. (2017). On the other hand, there was no difference in sex of dairy owner household heads between the production and breeding systems in the current study. Educational level of AI beneficiary and non-beneficiary households in urban and peri- urban areas of Adigrat was assessed to know the level of technology adoption (Table 2). Even though most of the beneficiary households in both production systems of the study area were literate, the overall educational background of AI beneficiaries was higher than AI non beneficiaries.

Thus, about 46.7% of urban AI beneficiary household heads of the target group accomplished a minimum of primary school education whereas 36.7% of urban AI non-beneficiary household heads of the target group completed primary school education. Moreover, about 33.3% and 23.3% of peri- urban AI beneficiary and none beneficiary households, respectively completed primary education. However, no statistical difference (p>0.05) was observed in the participation of educated and none educated households in adoption of dairy technologies. Abebe *et al*. (2014) from Ezha Districts of Gurage Zone, Southern Ethiopia reported that 37.50 % of dairy producers completed their primary education.

Table 2: Sex, and educational level of households based on production and breeding systems in Adigrat Area

Production system	Breeding System	Sex of household heads (%)		Educational level of household heads (%)				
		Male	Female	Read & Write	Secondary school	Diploma and above	Elementary school	Illiterate
Urban	AIB (n=30)	83.3	16.7	53.3	16.7	13.3	16.7	0.0
(n=60)	AINB (n=30)	73.3	26.7	60	3.3	6.7	26.7	3.3
	Mean	78.3	21.7	56.7	10.0	10.0	21.7	1.7
	X^2 value	0.88	p=0.35		5.14		p=0.27	
Peri- urban	AIB (n=30)	70	30	63.3	13.3	3.3	16.7	3.3
(n=60)	AINB (n=30)	76.7	23.3	60	13.3	0.0	10	16.7
	Mean	73.3	26.7	61.7	13.3	1.7	13.3	10.0
	X^2 value	0.08	p=0.77		4.19		p=0.38	
Overall (n=12) (%)		**91(75.8)**	**29(24.2)**	**71(59.2)**	**14(11.7)**	**7(5.8)**	**21(17.5)**	**7(5.8)**

P=Probability, X2= Chi-square value, AIB= AI beneficiary, AINB= AI non-beneficiary.

Cattle herd size and composition in Adigrat area

Average cattle holding size by production system is presented in Table 3. The overall mean cattle holding per household in the present study was 6.18±0.63.

Table 3: Average cattle herd size and composition by production systems in the study area

Variables	Urban (n=60)	Peri-urban (n=60)	Overall mean (n=120)
Total cattle/hh	7.13±1.23	5.22±0.26	6.18±0.63
Local cattle/hh	0.08±0.06	1.52±0.15	0.8±0.10
HF crossbreds/hh	7.05±1.23	3.70±0.24	5.38±0.64
HF herd structure			
Pregnant Cow	1.47±0.22	0.58±0.09	1.03±0.13
Lactating Cow	2.20±0.28	0.72±0.09	1.46±0.16
Dry cow	0.78±0.21	0.20±0.06	0.49±0.11
Open cow	0.15±0.15	0.25±0.07	0.20±0.08
Bull calf	0.67±0.21	0.12±0.05	0.39±0.11
Heifer	0.72±0.17	0.28±0.07	0.50±0.09
Weaned	0.92±0.17	0.83±0.08	0.87±0.09
Unweaned	0.50±0.12	0.22±0.06	0.36±0.07
Bull	0.05±0.03	0.37±0.07	0.21±0.04

HF=Holstein Frisian, AIB= AI beneficiary and AINB= AI non-beneficiary, hh=household

Urban areas had more cattle per head (7.13±1.23) than peri urban (5.22±0.26). The average mean HF crossbred holding size/hh in the study area was 5.38±0.64. Peri-urban had less (3.70±0.24) HF crossbred /hh as compared to urban (7.05±1.23). The result of the current study showed that urban dairy producers prefer to retain lactating (2.20±0.28) and pregnant (1.47±0.22) cows, respectively than the rest of dairy animals.

From the above results, the higher number of crossbreds in the urban production systems could be due to better market opportunities for fluid milk and milk products, availability of AI services, production system is also specialized type which was different from peri-urban beneficiaries who had additional breeds rather than milk and milk products for different agricultural activities and could be difficult for them to manage more improved cross breed animals (Alemshet *et al.* 2017). Therefore, introduction of crossbreds has to be supported with other interventions such as better feeding, housing, health care, and extension services in order to exploit the genetic potential of the animals and thereby improve income of dairy producers (Azage *et al.* 2013).

Artificial insemination delivery practices, and constraints in urban and Peri-urban areas of Adigrat

AI service delivery system in urban and peri-urban areas of Adigrat was conducted in two ways: stationed and mobile service delivery systems. Survey study and group discussion were conducted on AI technicians and dairy beneficiaries in urban and peri-urban areas of Adigrat on Artificial insemination delivery practices, and constraints confirmed as below in (Table 4). About 43.3% and

46.7% of urban and peri-urban AI beneficiaries, respectively were not satisfied with the overall AI technicians service delivery system.

Table 4: Survey results on major constraints hindering AI service efficiency in the study area

Variables	Response of AIB	Urban AIB (n=30) %	Peri-urban AIB (n=30) %	Over all (n=60) %
Efficiency differences among AIT	Yes	60	43.33	51.67
	No	40	50.00	45.00
	Unknown	0	6.67	3.33
Shortage of AIT	Yes	26.67	43.33	35
	No	73.33	56.67	65
Service satisfaction with AIT	Yes	56.67	53.33	55.00
	No	43.33	46.67	45.00
Access to AI service on weekends and holidays	Yes	70.00	56.67	63.33
	No	30.00	43.33	36.67
Heat detection (during milking and feeding)	—	70	63.33	66.7
		30	36.67	33.34
Training on AI service and heat detection	Yes	36.67	55.17	45.92
	No	63.33	44.83	54.1
Alternatives used if AIT fail to come	Use bull	63.33	66.67	65.00
	Wait next 21 days	36.67	33.33	35.00

AIB = AI beneficiary, AIT = AI technicians, % = per cent.

This may be due to different factors such as shortage and unavailability of AITs during the weekends and holidays. On the other hand, Riyad *et al*. (2017) in Tullo district, West Hararghe and Zerihun *et al*. (2013) in West Gojjam Zone, reported (69.17%) and (55.8%) level of dissatisfaction, respectively. According to Desalegn *et al*. (2009) most of the technicians didn't get proper trainings for upgrading their capacity. About 30% of urban and 43.3% of peri-urban households indicated that they did not get AI service on weekend and holidays. This is almost in line with the results of Riyad *et al*. (2017) and Zerihun *et al*. (2013) who reported 51.2% and 46% of the beneficiaries respectively did not get AI service on weekend and holidays. The better AI delivery services offered on weekends and holidays for urban as compared to peri-urban were due to better communication and accessibility. About 26.67% and 43.3% of the participants in urban and peri-urban areas respectively reported that there was shortage of AI technicians. Hence, 63.3 and 66.7% of urban and peri-urban AI service users, respectively, switch to bull service when AI technicians were absent. Whereas, about 36.7and 33.3% of AI users should wait for the next oestrus. High shortage (60%) of AIT was reported by Zerihun *et al*. (2013) in West Gojjam Zone Sekela district (60%). This result was incomparable with the reports of Riyad *et al*. (2017) who reported that 71.1% of the owners waited for the next oestrus as they are unable to get AI service during heat period while 28.9% used natural mating when they didn't get the service in Tullo district, West Hararghe. On the other hand, 66.7% of AI beneficiaries in the study area practices regular heat detection; whereas 33.34% of the beneficiaries do heat detection only during milking and feeding. Regular heat detection practice is relatively better in urban (70%) as compared to peri-urban (63.33%) beneficiaries, whereas, 30% of urban and 36.67% of per-urban areas (Adigrat area) have heat detection problem. The finding of the current study is nearly similar with the report of Gebregiorgis *et al*. (2016) who reported about 27.63% of the dairy owners of Tigray Regional State have problem of heat detection. Poor heat detection, lack of well-trained AI technicians, poor communication between AI technicians and producers, lack of awareness, heat detection problem and Time of insemination were among the major constraints for efficient AI service delivering system in the study area.

Laboratory analysis of post thawed frozen semen motility in Adigrat and the regional AI center (AIC), Tigray, Ethiopia

The overall mean percentage of frozen sperm motility at Adigrat and Regional AI centres was 52±1.01% (Table 5). This result was consistent with Alemayehu *et al.* (2015), Tadesse *et al.* (2012) and Desalegn *et al.* (2008) who reported 55.98±5.9%, 51.7%, and 53.2%, respectively for frozen sperm motility in selected Districts of Western Gojjam and Amhara Region AIC and from the National Artificial Insemination Centre (NAIC). Hunderra (2004) reported higher value (68.72±1.37) for semen motility from indigenous breeds of bulls which were kept at the National Artificial Insemination Center (NAIC). There was a significant difference (p<0.05) in sperm motility between the AI centers, where it was higher for Regional AIC (54.2%) as compared to Adigrat AI service centre (49.1%). Even though there was difference in sperm motility between the Regional and Adigrat AI centers, the value obtained in the current study lies within the acceptable range (40% and above sperm motility) for Artificial insemination service as recommended by IAEA and FAO (2005).The difference might be attributed due to differences in semen handling and storage practices, transportation from the regional to Adigrat AI centre where the spermatozoa was exposed to different environmental stresses. However, semen production year and blood level had not shown significant (p>0.05) effect in the present study.

Table 5: Mean (±se) frozen sperm motility in the study area

Variables	N	Individual progressive sperm motility (%)
Overall mean	60	52.0±1.01
Effect of AI Centers		*
Adigrat AI center	30	49.1^{b} ±1.38
Regional AI Centre	30	54.2^{a} ±1.41
Effect of blood level		Ns
100% HF	20	53.1±1.75
75% HF	20	51.7±2.01
50% HF	20	50.3±1.62
Effect of production year		Ns
2012	30	50.5±1.40
2013	30	53.0±1.52

N = number of observations; HF=Holstein Friesian crossbreed; Se = standard error, ns=non-significant.

Evaluation of live percentage of post thawed semen in Adigrat and the regional AI center (AIC), Tigray, Ethiopia

The overall mean live percentage of post thawed semen in Adigrat and the Regional AI centres was 55.9±0.87 (Table 6). The result found from the current study was lower compared with the finding of Desalegn *et al*. (2008) who reported 76.33% for crosses of HF with indigenous bull but in line with the report of Tadesse *et al*. (2012) who obtained 56.4% of live sperm from selected Districts of Western Gojjam zone. The present study indicated that frozen semen viability was significantly (P< 0.05) affected by AI centers (Adigrat and the Region); whereas semen production year and blood level had not shown significant effect (p>0.05) on frozen semen viability. The minimum acceptable level of viable semen for the post-thawed spermatozoa is 50% (IAEA and FAO, 2005). As the value of the current study was 55.9%, the live sperm of Adigrat AI service centre was found in the range of recommended level. Though, the value of this result lied with the acceptable level, great attention should be given for factors that could affect semen viability such as chilling, freezing and storage at different AI centers, keeping the optimum level of liquid nitrogen in the containers, temperature fluctuations, transportation of semen from regional to district AI service centre, and to the beneficiaries as those factors could cause further loss of semen viability.

Table 6: Mean (±se) frozen sperm viability (per cent live sperm) in the study area

Variables	N	Frozen semen viability (%)
Overall mean	60	55.9±0.87
Effect of AI center		*
Adigrat AI center	30	53.2^{b} ±1.14
Regional AI center	30	58.6^{a} ±1.13
Effect of blood level		Ns
100% HF	20	58.2±1.77
75% HF	20	55.8±1.54
50% HF	20	53.9±1.02
Effect of production year		Ns
2012	30	56.4±1.33
2013	30	55.5±1.14

N=number of observations, HF=Hole stain Frisian crossbreds, Se=standard error.

CONCLUSION

Therefore, it was concluded that shortage and efficiency of AIT are among the major constraints hindering AI service in the study area, whereas mean frozen semen motility and live sperm percentage in Adigrat and the Regional AI centers (AIC) were found within the accepted range.

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