ID: 420

Effects of sexed semen on fertility and sex ratio of calves in indigenous Arsi Cattle at Adami Tulu Agricultural Research Center

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Abstract

An on-station study was conducted at Adami Tulu Agricultural Research Center during 2021 to 2022/23 breeding season to evaluate the effect of sexed semen on fertility rate of cows, number of services per conception (NSPC), conception rate, sex ratio of calves born and the economics of using sexed semen in indigenous Arsi cattle. For evaluation purpose indigenous Arsi Breed cattle were selected from nucleus herd maintained at on station based on their parity, body condition and reproductive history and assigned to one of the following treatments. Animals in Treatment 1 were inseminated with conventional semen and Treatment 2 were inseminated with sexed semen. They were synchronized for estrus by injecting PGF2α hormone, whereas, those animals exhibited the sign of heat naturally were inseminated directly. Heat was detected by herdsmen in the early morning, mid-day, early evening and at nighttime. Standard procedure of semen handling and insemination was implemented during the study. Pregnancy diagnosis was performed by rectal palpation after 90 days of insemination. There was no significant difference (P>0.05) in NSPC between the treatments and the overall mean NSPC was 1.23±.049. There was no significant difference (P>0.05) in pregnancy rate between treatments. The pregnancy rate was 71% and 56.4% for conventional and sexed semen, respectively. The mean conception rate was 57.9% and 44% with conventional and sexed semen, respectively. There was a significant difference (P<0.05) in sex ratio of calves born between treatments. The average female calf obtained was 50% and 85% for conventional and sexed semen, respectively. The overall advantage of using sexed semen was 769,532 ETB and 15,390.64 ETB advantage per unit of sexed semen used. Sexed semen can be used as alternative artificial insemination technology for Arsi breed cows to produce more female calves for herd replacement. On-farm evaluation and demonstration of using sexed semen technology is important in potential areas suitable for dairy production.

Key words: *Sexed semen; conception rate; sex ratio*

Introduction

Naturally, it has been reported that the sex ratio among the mammals is 50:50 towards the birth of male and female offspring. However, depending on the demand of the livestock farmers, researchers have tried over the years to alter the ratio favoring the birth of a particular sex. Several such studies have considered different hypotheses viz. time of insemination, provision of different types of feeds and minerals, alteration of vaginal and uterine pH, use of sexed semen (De Graaf *et al.,* 2009), uses of certain chemicals. Observations of study by Khan *et al.,* (2012) indicated that alteration of sex ratio in cattle is financially attractive. In beef cattle production it can result in the birth of bull calves which have enhanced growth rate vis-a-vis those of the cow calves of the same age (Keane and Drenna, 1990). In contrary to the beef farms, dairy farmers are generally interested in female calves to maintain their herd. Furthermore, the requirement for a fewer male to female sex ratio (i.e., lower sex ratio) in dairy cattle is important when the herd replacement rates are high which can also help in improving the selection intensity (Badinga *et al,* 1985).

Most of the studies conducted on the sex ratio of calves produced by different insemination technologies have reported contradictory results. Birth of female calves is important especially among the dairy farmers or those who are associated with the dairy industry (Xu *et al.* 2000). Artificial insemination (AI) has been one of the widely accepted biotechnology that has revolutionized the optimum use of good quality sires. However small and medium scale dairy farms in different areas of Ethiopia have been complaining about more numbers of male calves being born following artificial insemination (AI) (Bekele, 2005, Frehiwet *et al.,* 2014) similar observations have also been reported by Skjervold and James, (1979) and Xu *et al.* (2000).
S. A. Holden and S. T. Butler, 2018 indicated that Sex-sorted semen is a revolutionary technology for cattle breeding. Utilization of sexed semen can increase the efficiency of both dairy and beef production, increase farm profitability and improve sustainability of cattle agriculture.

The use of sex-sorted semen in both dairy and beef production allows predetermination of calf sex with up to 90% reliability. More recent studies have demonstrated that sexed semen can be successfully used in both heifers and multiparous cows, (Butler *et al.,* 2014; Xu, 2014). Nevertheless, no research has been conducted on the effect of using sexed semen on the fertility of cows and sex ratio of calves in Arsi cattle breed. This study was conducted the following objectives:

Objectives

- To evaluate the effect of inseminating cows with sexed semen on the number of services per conception and conception rate and sex ratio of calves born
- To evaluate the economic benefit of using sexed semen for dairy producers

Materials and methods

Study area

The study was conducted at Adami Tulu Agricultural Research Center. The center is located at 167km south of Addis Ababa and situated at latitude of 7^0 9` N and $38^0$7`E longitude in semi-arid middle rift valley of Ethiopia. The area is situated at 1500 meters above sea level and the soil type of the area is fine, sandy loam and clay in the proportion of 34:48:18 respectively. The average annual rainfall is 760mm. The minimum and maximum temperature are 12.6 and 27^0c, respectively (ATARC, 2003).

Materials used

Experimental animals, sexed and conventional semen, liquid nitrogen, AI Gun, AI sheath, arm length glove and concentrate feeds. Sexed semen, Progeny tested frozen semen of Holstein Frisian sires of Worldwide Sires® (WWS), and Conventional frozen semen of Holstein Friesian sire reared at LDI were used.

Experimental animals

A total of 70 Arsi cows and heifers were selected based on several traits (parity, body condition, milk yield, mothering ability, free from reproductive diseases). Breeding was done from 2021/22 to 2022/23 breeding season.

Estrus synchronization: 2ml Lutylase hormone was injected to each cow after detecting the presence of responsive corpus luteum (CL) through rectal palpation. Animals exhibited signs of heat naturally were inseminated directly without the injection of hormone.

Heat detection: Cows were monitored by herdsmen and night guards for signs of heat (early in the morning, at daytime and late in the evening).

Breeding: Cows showing signs of estrus naturally or through administration of Synchromate hormone were inseminated with progeny tested sexed semen (obtained from Worldwide Sire ® (WWS) and conventional semen (obtained from LDI).
A standard semen handling and insemination procedure as recommended by IAEA (2005) was used to inseminate the animals. Cows noted in heat in the morning were inseminated in the afternoon and those identified in the afternoon were inseminated the next morning based on the “AM- PM guideline” (Peter and Ball, 1995).

Experimental design

The experimental animals were blocked based on their parity, age and body weight and assigned to one of the following treatments:
Treatment 1=Conventional Semen
Treatment 2= Sexed Semen

Collected data

Number of animals synchronized (treated with PGF2α), number of animals that come to heat, number of animals inseminated, number of services per conception, number of animals pregnant , number of calves born, sex ratio of calves at birth , General health data of the cows, cost of semen and other costs.

Pregnancy rate was calculated using the following formula:

$$\text{Pregnancy } Rate\ (\%) = \frac{Number\ of\ pregnant\ animals}{total\ number\ of animals\ inseminated} X100$$

Conception rate was calculated using the following formula:

$$Conception\ Rate\ (\%) = \frac{Number\ of\ pregnancies}{Number\ of\ inseminations} X100$$

Economics of sexed semen

Economics of using sexed semen was estimated by using simple and flawed model of the economics of sexed semen recommended by Fetrow J. (2007). The cost of both sexed and conventional semen per conception was considered as cost incurred. The sale price of 3-month male calves and yearling female heifers were estimated by dairy producers and individuals having experience in buying and sale of crossbreed animals in the area. Additionally the rearing cost of female calves until yearling age was estimated both by experienced dairy producers and technically by researchers. The profit of female claves is calculated as the difference between the selling price minus rearing cost of heifers (labor cost, price of milk consumed by heifers, veterinary costs, and costs of concentrate and roughage feeds. Finally, the overall advantage of sexed semen and advantage per unit of sexed semen was calculated as follows:

Advantage of sexed semen = Net income of sexed semen – Net income of conventional semen

$$\text{Advantage per unit of sexed semen used} = \frac{\text{Overall advantage of sexed semen}}{Total\ unit\ (dose)\ of\ sexed\ semen}$$

Data analysis

Collected data were entered into MS excel and data were analyzed using descriptive statistics and Chi square test. Significance was declared at P<0.05.

Results and Discussions

Number of services per conception

The result indicated that there is no significant difference in services per conception (NSPC) between the treatments and the overall mean NSPC was 1.23±.049 (Table 1). The current result is in line with reports by different authors who reported services per conception ranges from 1.06 to 2.6 (Million *et al.,* 2006; Genzebu *et al.,* 2016).

Table 1. Average number of services per conception of Indigenous Arsi cows inseminated with conventional and sexed semen

Treatment	N	Mean ± SE	P value.
Conventional semen	31	1.23±.076	
Sexed semen	39	1.28±.082	0.624
Total	70	1.26±.056	

Pregnancy rate

The result indicates that there is no significant difference in pregnancy rate between treatments (Table 2). The pregnancy rate is 71% and 56.4% for conventional and sexed semen, respectively. The current result is higher than the pregnancy rate reported by Seidel and Schenk (2002) who reported 43 to 62% and 31 to 42% pregnancy rate for conventional and sexed semen in different field experiments. The difference might be due to the environment in which the trial was conducted since our experiment was conducted at on station and the previous study was conducted on-farm.

The current result on pregnancy rate by using sexed semen is comparable to the results of Cerchiaro *et al.* (2007) who reported pregnancy rate of 51% for sexed semen in the field study conducted on Holstein Friesian cows in Italy.

Conception rate

The mean conception rate is 57.9% and 44% for conventional and sexed semen, respectively. The conception rate for sexed semen was lower than conventional semen. Norman *et al.* (2010) indicated that the process of sorting sperm cells reduces the conception rates in dairy cattle. The conception in current study was higher than the result reported by Norman *et al.* (2010) who reported the conception rates of 30 and 25% by using conventional and sexed semen.

Table 2. Pregnancy rate of Indigenous Arsi Cows inseminated with conventional and sexed semen

Treatment	Parameter	Pregnancy rate		Total	P value
		Positive	Negative		
Conventional semen	N	22	9	31	
	%	71	29	100	
Sexed semen	N	22	17	39	0.0158
	%	56.4	43.6	100	
Total	N	44	26	70	
	%	62.9	37.1	100	

The result of conception rate observed in the current study was lined with the report of Anonyms (2020) who reported the conception rate of (50.2% vs. 60.3%, for sexed and conventional semen, respectively. In contrast to this Oikawa K, *et al.* (2019) and Sahereh Joezy-Sh. e*t al.* (2017) reported 47.3% and 48.3% conception rate by using sexed semen and 63.8% using conventional semen in Holstein cows. The difference might be due to the number of data taken and easily accessibility of fresh processed semen we use imported sexed semen.

Sex ratio of calves born

The result indicated that there is a significant difference (P <0.05) in sex ratio of calves born between treatments (Table 3). The rate of obtaining female calf was 85% and 50% for sexed semen and conventional semen, respectively. Albert De Vries (2010) indicated that sexed semen with relatively more X- chromosome bearing sperm had a greater chance to result in female calf. It is justifiable that sexed-sorted semen produces a greater number of single sexes as the desire of the producers, and we used X-chromosome sorted semen.

The current result on calve sex ratio was in line with previous reports on sexed semen between 85 and 91% by Tubman *et al.* (2004); Borchersen & Peacock (2009); DeJarnette *et al.* (2009); Norman *et al.* (2010). Norman *et al.* (2010) and Alemayehu and Girma (2019) reported 48% and 42.9% female calf ratio by using conventional semen, respectively.

Table 3. Sex ratio of calves born from Indigenous Arsi Cows inseminated with conventional and sexed semen

Treatment	Parameter	Sex of calves born		Total	P value
		Female	Male		
Conventional semen	N	11	11	22	
	%	50	50	100	
Sexed semen	N	17	3	20	0.018
	%	85	15	100	
Total	N	28	14	42	
	%	66.7	33.3	100	

Economics of sexed semen

The overall advantage of sexed semen and advantage per unit of sexed semen used were calculated and the result revealed that the use of sexed semen is economical. The overall advantage of using sexed semen was 769,532 ETB and 15,390.64 ETB advantage per unit of sexed semen used. The current result is contrast with the findings of De Vries (2008) who reported that the use of sexed semen across all heifers is not necessarily profitable. The difference might be due to the difference in conception rate as they reported lower conception rate of sexed seme than the current finding.

Conclusions and Recommendations

The number of services per conception was similar across the types of semen used for insemination. Conception rates have a positive correlation with the number of pregnancies show similar trends with pregnancy rate across treatments.

Use of sexed semen is economical and has an advantage over conventional semen.
Maximum care must be taken by Artificial inseminators and farm owners on using sexed semen to attain best conception rate.
Sexed semen can be used as technological intervention for dairy farms who needs more female calves for herd replacement. Use of sexed semen needs to be evaluated and demonstrated at on farm level in potential areas suitable for dairy production.

Table 4. Economics of conventional and sexed semen used in Indigenous Arsi cows

Parameter	Unit	Conventional semen	Sexed semen
Conception rate	%	71	44
Amount of semen used	Number	38	50
Semen price	ETB	14	3,000
Total cost of semen	ETB	532	150,000
% of heifers	%	50	85
Number of heifers	Number.	11	28
% of bulls	%	50	15
No of male calves	Number.	11	14
Price of heifer	ETB	80,000	80,000
Cost to rear a heifer	ETB	27,000	27,000
Profit per heifer	ETB	53,000	53,000
Sale price of a bull calf	ETB	6,000	6,000
Income from heifers	ETB	583,000	1,484,000
Income from bulls	ETB	66,000	84,000
Total income	ETB	649,000	1,568,000
Total income minus semen cost	ETB	648,468	1,418,000
Advantages of sexed semen	ETB	769,532.0	
Advantage per unit of sexed semen used	ETB	15,390.64	

Acknowledgement

The authors would like to thank Oromia Agricultural Research Institute for funding this experiment. Animal Biotechnology Research Team at Debrezeit Agricultural Research Center and Dr. Tamirat Degefa for material and technical support during the study.

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