International Journal of Advanced Research in Biological Sciences
ISSN: 2348-8069
www.ijarbs.com
DOI: 10.22192/ijarbs Coden: IJARQG (USA) Volume 8, Issue 11 -2021

Research Article

DOI: http://dx.doi.org/10.22192/ijarbs.2021.08.11.014

On station evaluation of estrus response to single shoot prostaglandin synchronization and conception rate of sexed semen in dairy cattle

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Abstract

The goal with sexed semen is to produce a calf of a specific sex. Estrus synchronization and artificial insemination programs are sides of a coin and it was born to boost the success of artificial insemination. Once prostaglandin (PGF2α), identified as the luteolytic agent, it will operate in single and double injection systems alone or combination with other hormones. The ultimate aim of the current study was to evaluate effectiveness of single shoot prostaglandins as a luteolytic agent and conception rate and gender skew of sexed semen with different age, breed and body condition score. The current study showed that, the overall estrus response rate, conception rate and female skewto single shot injection of prostaglandin irrespective of breed, age and body condition score was (20/24; 83.3 %), (18/20; 90%) and (17/18; 94.4%) respectively. Breed wise, estrus response rate, conception rate, female skew and calves mean birth weight was higher (13/14; 92.8%),(12/13; 92.3%), (12/12; 100%) and 33.1kgin Boran Holsteins cross breed compared to (7/10; 70%, (6/7; 85.7%), (5/6; 83.3%)and 25.5kg in Boran breed respectively. Similarly, the current study showed that animals in range of 5-8 body condition score has good response rate for the treatment. Unlike other findings statistically insignificant higherestrus response rate, conception rate, female skew and calves mean birth weight was recorded (11/13; 84.6%), (10/11; 90.9 %), (10/10; 100%) and 30.2 kg cows compared to (9/11; 81.8%), (8/9; 88.9 %), (7/8; 87.5%) and 28.4 kgin heifers respectively. Hence, from the findings of this study it can be inferred that single shoot prostaglandin was effective to synchronize both cows and heifers of crossbred and local in good body condition state. Moreover, it is possible to conclude the conception rate or fertility performance with sexed semen will be equal to or greater than that of conventional semen. The possible explanation for this observation was proper animal selection, follow up for behavioral estrus manifestation, following the proper timing of AI that was particularly suited to sexed semen (i.e., delayed AI relative to heat onset). Therefore, from the obtained results, it is an indicative that introduction of estrus synchronization with sexed semen technology especially for a country like Ethiopia having huge number of local cattle (about 97.4% %) of the total cattle population, to produce cross bred dairy cattle and replacement heifers.

Keywords: Conception rate, Estrus response rate, Prostaglandin, Sexed semen

Introduction

According to CSA (2020/21) report, Ethiopia is the first from Africa and sixth from world in cattle population with latest estimated figure of 70 million heads. However about 97.4% % of the total population are indigenous cattle and become source of the milk produced (>97%) in the country. Unfortunately, the average milk yield per cow per lactation is much lower than their contemporary species' produce in other parts of the world. Hence, in order to improve reproductive efficiency of cattle; reproductive technologies including multiple ovulation and embryo transfer (MOET), artificial insemination (AI), sexed semen technology, and estrus synchronization are in the forefronts and have major impact on improving productivity of dairy cows.

Sexed semen is semen contains an enriched proportion of either X-bearing chromosome (female) or Y-bearing chromosome (male) sperm cells have been modified from the natural mix through sorting and selection. Sorting is based on flow cytometrical cell sorting for DNA content of sperm (Weigel, 2004; Seidel, 2007). The bovine Y-chromosome bearing sperm contain 3.8% less DNA than the X-chromosome bearing sperm. The goal with sexed semen is to alter the sex skew (sex ratio) of the offspring toward a desired gender. When using sexed semen, about 90% accuracy of the new born offspring will be from the required sex (DeJarnette et al., 2009) as compared to conventional semen where male: female ratio is 50:50.

Because of lower doses of sperm per straw (approximately 2 million), and possibly a negative effect of the sorting process, sexed semen has a shorter duration of viability in the female reproductive tract (12–16 h) results in lower fertility compared with conventional sperm (Garner and Seidel, 2003; DeJarnette et al., 2008). In the 2018 field trial, 25% of the farms achieved fertility performance with sexed semen that was equal to or greater than that of conventional semen (Drake, Aublet, Holden, & Butler, n.d.). One possible explanation for this observation was that those particular farms had decision rules for the timing of AI that was particularly suited to sexed semen (i.e., delayed AI relative to heat onset).

Estrous synchronization is the process of coordinating the reproductive cycle in female mammals targeting to come to heat within a short time frame (36 to 96 hours).Hence, regardless of type of semen (sexed or conventional) used, estrus synchronization and artificial insemination (AI) programs are sides of a coin (Lijalem et al., 2015) and estrous synchronization was born to boost the success and efficiency of artificial insemination. Application of estrous synchronization could improves reproduction efficiency by reducing the calving interval, schedule calving season with availability of feed and market, production of uniform calf crops in the following season, make breeding logistically easier and efficient use of AI technique (Galina & Orihuela, 2007; Islam, 2011; Girmay *et al*., 2015).

Estrus synchronization works either by controlling follicular development, promoting ovulation in anestrus cattle, regressing the corpus luteum (CL) in cyclic animals or synchronizing estrus and (or) ovulation (Lucy *et al*., 2004). Prostaglandin (PGF2α), is produced naturally in different parts of the body especially in the ovary to cause functional or structural regression of the corpus luteum. PGF2α, after it is identified as the luteolytic agent, its commercialization follows with natural and synthetic (potent analogs) forms to shorten the luteal phase, which makes it economically feasible for synchronizing estrus (Cordova-Izquierdo et al., 2009; Diaz et al., 2005; Ginther et al., 2010; Paul et al., 2015; Sprott & Carpenter, 2007) and M. C. Lucy et al. (2004). It will operate in single and double injection systems alone or combination with other hormones. Nowadays, a variety of protocols for estrus synchronization in cattle is designed and implemented (Gizaw *et al*., 2016). However, the selection of technically right and practically feasible protocol is the base for success (Gizaw *et al*., 2016; Gupta *et al*., 2008). Therefore, this research work is aimed;

- To evaluate effectiveness of single shoot synthetic prostagland insluteolytic hormone incyclic Boran and Boran Holsteins crossbred
- To know the conception rate and gender skew of sexed semen
- To know effect of parity and body condition score on response of single shoot synthetic prostaglandins based synchronization conception rate.

Materials and Methods

Study Area

This study was carried out from August 2020to august 2021. The experiment was conducted at Debre zeit agricultural research center (DZARC), animal biotechnology research program, of Ethiopian Institute of Agricultural Research (EIAR), Bishoftu, located about 45 km east of Addis Ababa, the capital city of Ethiopia (8°46′13.57"N, 38°59′50.45"E) at an altitude of 1920 masl.

Experimental animals

Boran and Boran*Holstein heifers and cows in their first and second parity were used for this study. Selected animals had a body condition score (BCS) 3-8 on a scale of 1 to 9; (when 1=emaciated; 9 =obese) and aged between 3 to 6 years. All the experimental animals were maintained as a group and were housed in semi-open system. Experimental animals were provided with a feed of different mixes: *tef* (*Eragrostis tef) straw* and grass (*Andropogon abyssinicus*) hay as a basal diet and supplemented with commercially prepared concentrate, mineral salts, and alfalfa green fodder. Management of these animals was nearly similar and sometimes they were released extensively for free grazing. Water was provided *ad-libitum*. Animals were regularly dewormed against a common parasitic disease and vaccinated for lumpy skin disease (LSD), foot and mouth disease (FMD), and other common infections.

Treatment Protocol

A total of 24 (Boran 10 and Boran*Holstein 14) animals were selected from a total of 36 examined animal based on transrectal palpation for the presence of well-developed CL in either ovary and were injected with 2 ml CICLAR hormone(Synthetic prostaglandin luteolytic agent) intramuscularly. Red/Orange fluorescent colors coated ESTROTECTwere applied on halfway between the hip and tail head perpendicular to the spine after brushing the hair thoroughly to create optimal condition for adhesion (Figure 1). Hence with each mount, the surface will gradually turn from silver to its indicator color indicating a true standing heat. As per the manufacturers recommendation aproxmetly 50% of the silver rub off coat removed should indicate standing heat. Sexed sperm cells often remain fertile for a shorter period of time in the female reproductive tract following insemination; approximately 18 to 24 hours (Thomas.J, 2021) after the start of that female's standing heat behavior within 2 to5 days after prostaglandin injection (Figure 2).

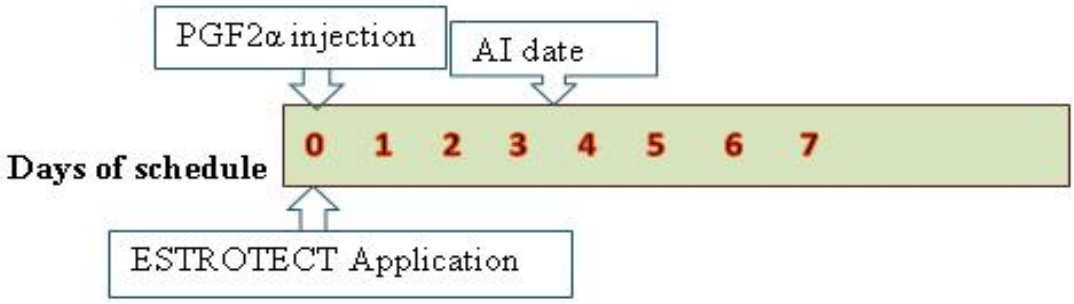

Figure 1: Synchronization and artificial insemination protocol

Figure 2: Synchronized animals and ESTROTECT used as a heat detector aids,Red circle shows activated / rubbed off ESTROTECT.

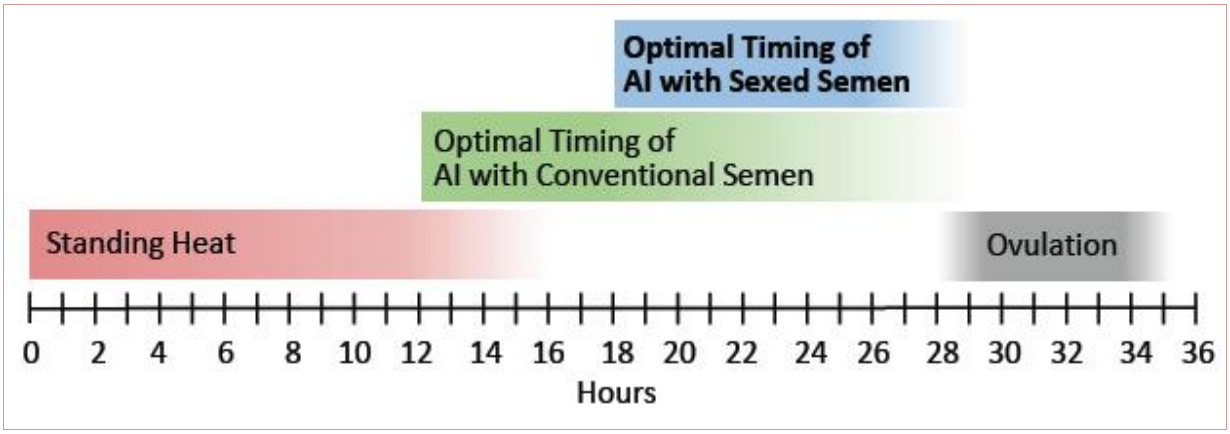

Figure 3: Optimum time of Artificial insemination with sexed semen (Thomas.J, 2021)

Data Collected

Age of the animals, body condition score of the animals, parity, corpus luteum orientation, date of hormone treatment, date of oestrus detection and insemination, sire ID, pregnancy rate calve birth weight and calve sex.

Results

In this study, the results of animals' response to PGF2α treatment, number of inseminated animals, conception rate (CR),sex of new born calves, calve gender skew and mean of calves birth weight evaluation with respect to breed, age and body condition score have been presented in figure 1and table 1 and 2 respectively.

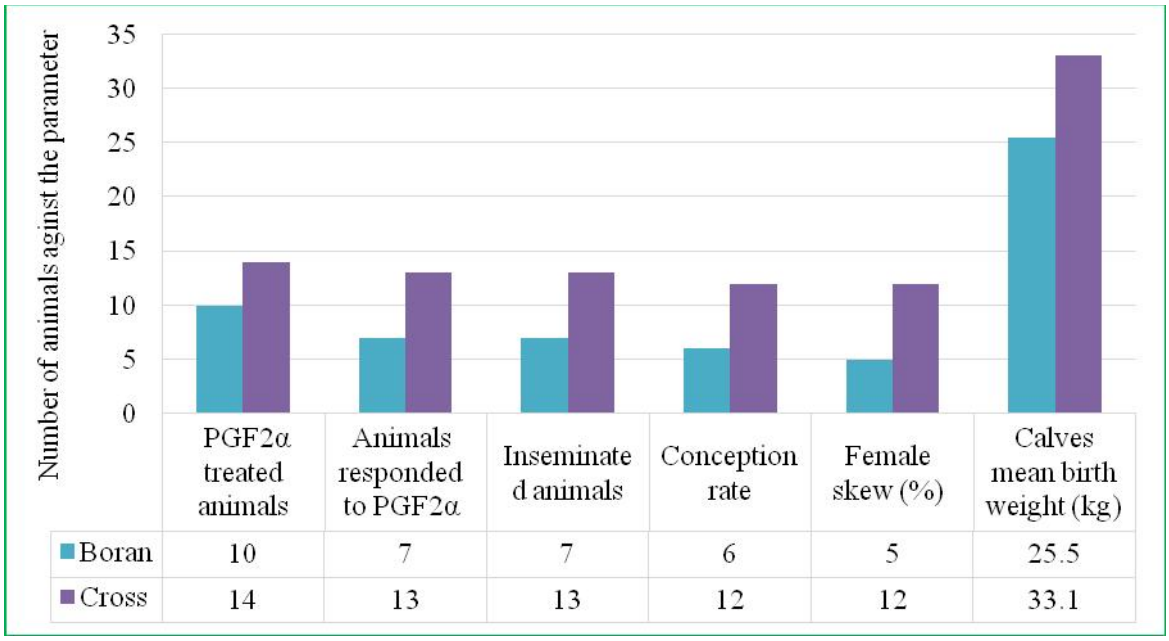

Figure 1: Evaluation in variation of oestrus response, conception rate, calve sex ratio and calves mean birth weight in local (Boran) and crossbred (Boran*Holstein) in cattle inseminated with sexed semen of the same sire.

Calves born from Boran *Holsteins Friesian dam using sexed semen

Calves born from Boran dam using sexed semen

Table 1: Evaluation in variation of oestrus response, conception rate, calve sex ratio and calves mean birth weight due to variation in age (heifers and cows) in cattle inseminated with sexed semen of the same sire

Injected with PGF2α		Animals responded to PGF2α	Number of inseminated animal	Pregnancy rate	Female skew (%)	Calves mean birth weight [kg]
Age	Number of animals					
Heifers	11	9 (81.8%)	9	8 (88.9 %)	7 (87.5%)	28.4 kg
Cows	13	11(84.6%)	11	10 (90.9 %)	10 (100%)	30.2 kg
Total	**24**	**20 (83.2%)**	**20**	**18 (90%)**	**17 (94.4%)**	------

gx

Table 2: Evaluation in variation of oestrus response, conception rate, calve sex ratio and calves mean birth weight [kg] due to variation in body condition scorein cattle inseminated with sexed semen of the same sire.

Injected with PGF2α		Animals responded to PGF2α	Number of inseminated animal	Pregnancy rate	Female skew (%)	Calves mean birth weight [kg]
BCS	Number of animals					
3-4	2	1 (50 %)	1	0	-	-
5-6	12	11 (91.7%)	11	10(91%)	9 (100%)	29.9
7-8	10	8(80 %)	8	8 (100%)	8 (100%)	28.7
Total	**24**	**20**	**20**	**18**	**17(94.4%)**	**-------**

Discussion

One-shot prostaglandin protocol in cow and heifers estrus synchronization

Many estrus synchronization protocols can induce 75 to 90% of the cycling animals to display estrus within a 5 day period. These days, prostaglandin is used to synchronize oestrus in dairy cattle operations to boost the efficiency of AI by inducing the regression of the CL (Murugavel *et al*., 2010; Diaz *et al*., 2005). The luteolytic prostaglandin works only in animal with cycling ovary and can be utilized to schedule estrus and ovulation for an individual cycling animal or a group of animals. This allows control of the time at which cycling cows or heifers can be bred. Prostaglandin can be used in a breeding program with single or double shot injection scheme. Prostaglandin is the first method of heat synchronization that depends on the presence of a functional CL particularly in the diestrus stage of the estrous cycle (day 7 to 17 of the cycle) (Cordova-Izquierdo *et al*., 2009). Its effectiveness usually affected by heat stress, asynchronous ovarian events exhibiting incomplete or delayed luteolysis, and weak or delayed estrous (Lamb, 2001 and Dejarnette, 2004).

According to the results shown in Table 1, for this study, the overall estrus response to single shot injection of PGF2α irrespective of breed, age and body condition score was (20/24, 83.3%). Estrus response rate with respect to age was, 81.8 in heifers and 84.6% in cows. Findings reported by Weldegebriall, (2015),of the same synchronization protocol on local and Holstein Friesianshowed that oestrus rate of cows to PGF2α is 91.67% while, the oestrus response rate of heifers was 93.02%, which is higher than the present study. This is probably associated with small sample size of the experimental animal.

Sexed semen fertility in heifers and cow

The aim of sexed semen is to produce a calf of a specific sex. The predetermining the sex has valuable impact on livestock industry because of its economic gains. Females are essential for milk production while males are required for meat production (Espinosa-Cervantes and Córdova-Izquierdo, 2012).Timing is everything with sexed semen. With sexed semen, it is more critical to inseminate at the right time relative to ovulation rather than closer to ovulation. Successful use of sexed sperm requires proper management of cattle and farm, careful handling of sperm and use of a skilled AI technician (Seidel, 2007).Conception rate with sexed semen is directly proportional to reproductive efficiency, and as the reproductive management deteriorates conception rate also lowers.

Research and field evaluations have shown that the fertility of sexed semen is approximately 80% of the fertility of conventional semen (DeJarnette et al., 2009). This holds in both heifers and cows. From the recent studies, it was observed that conception rate in cows and heifers were (10/11= 90%) and (8/9=89.9%) respectively. Result of summarized data from 2012 to 2016, by Oikawa *et al*.,(2019) showed that, the mean of raw conception rate was 47.3% with sexed semen. More over Summerizing data from 2006 to 2008 for US Holsteins in DHI herds showed 41% conception rate in sexed semen (Norman., *et al*., 2010). Accordingly, the conception rate obtained in the present study result is very good. This is probably a reflection of the high degree of the efficacy of the treatment regime. Equally important is also the careful selection of the animals on the basis of body condition score, and reproductive tract scores (reproductive phase), closely following up and managing animal, proper heat detection and insemination at the right time for sexed semen.

With regards to female percent (female skew), sexed semen produced nearly about 7/8 = 87.5 %) in heifers and (10/10 =100%) in cow respectively (Table 1).Again female and male calves produced by using sexed semen were significantly (P<0.01) higher and lower respectively.From the work of Norman*et al*(2010)summarizing theextent of sexed semen used from 2006 through 2008 by calf sexfor US Holsteins in DHI herds showed that for single births from sexed semen, a high percentage of female calves (female skew) resulted (91.0% for heifers and 89.3% for cows).On the other hands, for single births from breedings with X-bearing semen, Borchersen and Peacock (2009) and DeJarnette *et al.* (2009) reported 91 and 89% female calves in heifers and cows, respectively. Moreover, Seidel, (2003) and De Vries (2010) reported that the female: male ratio of calves produced by sexed semen was assumed to be 90:10 that is 90% female skew. Breed wise, as indicated in Figure 1, estrus response rate, conception rate and calves mean birth weight was higher in Boran* Holsteins breed than in Boran. Similarly mean calves birth weight was higher in Boran* Holsteins (33.1kg) than Boran (25.5 kg) breed.

Evaluation of the body condition (Noakes *et al*., 2001) is an important tool to determine which animals are fit to receive the hormonal therapy. Apparently the fact that in the present investigation the animals with body condition score 5-6 (91.7%) and 7-8 (80 %) responded favorably to estrus synchronizationthan the animals with body condition score of 3-4 (50%) in the present research.

Conclusion and Recommendation

As a conclusion from the findings of this study it can be inferred that prostaglandin was effective to synchronize both postpartum local and cross bred cows and heifers. Unlike other reports, from this study, the conception rate was higher, hence this study was conducted on station. Hence all the procedure from selection to insemination was done carefully. Estrus induction/ synchronization will give an opportunity to schedule the calving time with feed availability, to schedule the milk yield availability with the consumption demand and the animal can produce more calves in her life time by reducing the calving interval .Moreover, the study showed that sexed semen gives good conception both postpartum local and cross bred cows and heifers having good (5-8) body condition. Therefore, application of sexed semen with estrous synchronization is important to produce a group of calves' uniform in age and sex as a replacement stock. Depending on this study the following recommendation are forwarded:-

- The excellent rate of estrus response in the present study confirms the effectiveness of prostaglandin results obtained previously by another study.
- The higher pregnancy rates obtained highlights, careful selection of the animal, at the start of the experiment, proper heat detection, proper semen handling and insemination following the optimal timing for sexed semen.
- From the obtained results, it is an indicative that introduction of estrus synchronization with sexed semen technology especially for a country like Ethiopia having huge number of local cattle (about 97.4% %) of the total cattle population, to produce cross bred dairy cattle and replacement heifers

Conflict of interest

The authors declared no potential conflicts of interest relative to the research, authorship, and/or publication of this article.

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DOI:10.22192/ijarbs.2021.08.11.014

How to cite this article:
Sayid Ali, and Tamrat Degefa. (2021). On station evaluation of estrus response to single shoot prostaglandin synchronization and conception rate of sexed semen in dairy cattle. Int. J. Adv. Res. Biol. Sci. 8(11): 124-132.
DOI: http://dx.doi.org/10.22192/ijarbs.2021.08.11.014