Evaluation of Factors affecting Number of Services Per Conception for Sahiwal x Friesian Crossbred Cattle in Kenya

Mwangi S.I.*, Waineina R.W. and Ilatsia E.D.

Kenya Agricultural and Livestock Research Organisation, P.O. Box 25-20117, Naivasha

*Corresponding author e-mail: *mwangisamson32@gmail.com*

Abstract

The mean number of services per conception is based on data from served cows and is an estimate of fertility in dairy herds. Artificial insemination data for 1380 cows (2000 to 2021) from KALRO- Naivasha dairy herd under the artificial insemination program were analyzed using a mixed linear model. The effects of parity of cow, sire used, month, time (AM and PM), and year of insemination were evaluated. The individual animal was included in the evaluation and was fitted as a random effect. The parity ($p<0.0001$), sire used ($p<0.0001$), year ($p<0.0001$) and month of insemination ($p<0.01$), and individual cow effect ($p<0.0001$) were found to be significant factors influencing the number of services to conception. The season and time of insemination either in the morning (AM) or afternoon (PM) were not significant ($p \geq 0.05$). The average number of services per conception per parity was 2.3. The analysis of the findings highlights that conception rates are influenced by multiple environmental factors, emphasizing the need to consider these factors when implementing strategies to enhance cow fertility. Strategies that can reduce the number of services per pregnancy would reduce the number of animals culled for infertility and therefore eventually reducing on production costs. Investigation of other factors reflecting on health, general management, and bull factors would further contribute to improving overall cow fertility for Sahiwal X Friesian Crossbreds in Kenya.

Keywords: Artificial insemination, fertility, dairy cattle, conception rates

Introduction

Privatization of Artificial Insermination (AI) services in Kenya started in 1992 as an approach to increase its adoption by farmers in marginal areas (Khainga *et al.,* 2018). These structural reforms have led to as much as 95% of inseminations conducted by private AI service providers and cooperatives (Makoni *et al.,* 2014; Omondi *et al.,* 2017). Despite these changes, the progress is still low owing to a number of technical, system, financial and managerial problems (MoALF, 2019; Omondi *et al.,* 2017). Subsequently, this has contributed to low conception rates and repeat breeding of inseminated cows.

Desalegn (2008) found that at the country level, conception rates to first inseminations ranged from 7.14 to 40.23% in a study on dairy cows in Ethiopia. Additionally, most studies have indicated that the field AI efficiency in most developing countries ranges between 2.5 and 3 inseminations per conception (Gebremedhin, 2008; Tefera *et al.,* 2014), which can be classified as poor fertility and efficiency that requires immediate attention for improvement (Schuster *et al.,* 2020). This poor fertility in cattle has been described as one of the major limiting factors that determine longevity (De Vries & Marcondes, 2020). Studies have shown that few cows survive beyond the fifth parity due to poor fertility (Wathes *et al.,* 2008; Schuster *et al.,* 2020) which leads to fewer number of calves born per cow limiting the availability of potential replacement stock born within a herd (Wathes *et al.,* 2008; De Vries & Marcondes, 2020). Several factors have been reported to influence the conception rate and fertility of pure-breed cattle reared under the artificial insemination (AI) system. The majority of previous studies on the effect of various factors on the fertility of AI-reared cows were conducted on smallholder dairy farms several years back. As a result, adequate information on current AI performance and factors influencing its efficiency is lacking in all farmers' management systems in Kenya. The objective of this study was to assess the effect of different factors on the number of services per conception under farm settings, with the aim of providing recommendations to enhance the effectiveness of AI delivery systems in the future.

Materials and Methods

Artificial insemination data were obtained from animals served at the National Sahiwal Stud (NSS) at KALRO Naivasha, Kenya, from 2000 to 2021. Additional information included IDs of the cow and bull used, time of insemination (AM and PM), Season of insemination, parity and number of inseminations. The study encompassed a population of 9526 animals, consisting of both heifers and cows, with a maximum of nine parities. The cows are kept under a strict management system with identical feeding conditions, as they are allowed to graze in the fields during the day and are given water, mineral supplements, and hay on occasion during dry seasons. Regular health management practices such as spraying, deworming, and vaccinations are carried out. Because the farm is fenced, there is less chance of coming into contact with flocks from other farms.

The descriptive statistics and Proc GLM of SAS 2004 were used to analyze data generated on factors affecting conception rate. The factors included were: effects of bull, cow, season of insemination (Season 1 {December to February – Dry season}, Season 2 {March to May – Long rains seasons}, Season 3 {June to August – cold season}, Season 3 {September to November– short rains season}, year and month of insemination and time of insemination (AM and PM).

The PROC MIXED procedure of SAS 2004 was used for fitting a linear mixed-effect model. The model was used to analyse the relationship between number of inseminations and the predictor variables and random intercepts. The linear mixed-effects model was fitted was as follows;

$$Y_{ij}=\beta_0+(\beta_1\times Parity_{ij}) + (\beta_2\times YoI_{ij}) + (\beta_3\times MoI_{ij}) + (\beta_4\times Time_{ij}) + u_{0j} + \epsilon_{ij}$$

where:

- Y_{ij} is the response variable (no of inseminations) for observation *i* in group j.
- β_0 is the overall intercept.
- $\beta_1, \beta_2, \beta_3, \beta_4$ are the fixed-effect coefficients for Parity, YoI (Year of Insemination), MoI (Month of Insemination), and Time for Insemination, respectively.
- u_{0j} is the random intercept for the subject (either Cow or Bull) j.
- ϵ_{ij} is the error term for observation i in group *j*.

Tukey's HSD was used to test for fixed effects level mean differences based on the Studentized range statistic.

Results and Discussion

The overall conception rate after the first insemination was less than 50% (42.76%) as shown in Table 1. Additionally, more than 30% of the cows were inseminated three to seven times before conception. The overall mean conception rate after the first service in this study was 42.8%, which was higher than the average national conception rate in Ethiopia (27.06%) reported by Desalegn (2008) but lower than the report of tropical researchers such as Galina and Arthur (1990), who reported higher proportions ranging from 63 to 71%. With increasing service number, there was a gradual decrease in conception rate (Table 1). The average rate of conception for the first service was 42.8%, compared to 9% for more than five services. Lower conception rates as service number increases could be attributed to an increasing percentage of repeat breeders

Table 1: Frequency distribution of animals based on the number of services per conception

No of inseminations	Frequency	Percent
1	4073	42.76
2	2342	24.59
3	1348	14.15
4	795	8.35
5	428	4.49
6	250	2.62
7	290	3.04

as they are presented for successive services. A variety of factors can explain the differences between studies. When using AI to breed cattle, the goal should be to achieve conception rates of 40 to 60%. (Arthur *et al.,* 1996; Wathes *et al.,* 2014; Mekonnen and Berhe, 2023).

With the exception of time, all factors evaluated in this study were significant (P>0.05), as shown in Table 2. This implies that whether insemination is performed in the morning (AM) or evening (PM) has no effect on the number of services per conception. However, accurate detection of oestrus is critical in any dairy cattle reproductive management program. The effect of parities was significant (P>0.05) as shown in Table 2. After performing mean separation on various parities as shown in Table 4, the study showed that the average number of services per conception increased significantly with the increase of parities. This is in line with previous studies that have shown that heifers tend to have higher conception rates than cows at advanced parities (Bo *et al.,* 2019; Wathes, 2022).

Significant effects of parity, year of insemination, and month of insemination suggest that these factors are important in explaining the variation in the number of inseminations. Additionally, there was no significant difference observed across various seasons despite month of insemination being significant (Table 4).

Table 2: Effect of various fixed effects on the number of services per conception

Effect	Num DF	F Value	Pr > F
Parity	5	5.41	<.0001
Year	21	20.14	<.0001
Month	11	4.05	<.0001
Time	1	0.61	0.4341
Season	3	4.14	0.061

Table 3 indicates the variability in the response variable specific to individual cows and sires. The estimate of 0.40 for cows suggests that there is substantial variability among individual cows in regard to number of inseminations per conception. The smaller estimate of 0.01 for the for bulls indicates that there is less variability among individual bulls in terms of number of inseminations per conception compared to cows. This information could have practical implications for management decisions, such as personalized interventions or treatments for individual cows and bulls.

Table 3: Parameter estimates for the random effects on the number of services per conception

Subject	Estimate
Cow	0.3968
Bull	0.01049

The presence of significant differences in conception rates between parities in this study was consistent with other studies (Mukasa-Mugerwa *et al.,* 1991; Kaziboni *et al.,* 2004; Woldu *et al.,* 2011; Mekonnen and Berhe, 2023) that found significant differences between parities. Mukasa Mugerwa *et al.* (1991) found that cows in the second (68%) and third (23%) parities had significantly higher conception to first service rates than cows in the fourth (7%) and subsequent calving (2%). The consistency of these studies is due to environmental and other factors that influence conception rates.

According to this study, seasonal effect was not significant on cows' conception rates. However, this is in contrast with other research that has shown that the effect of season is more pronounced in lactating dairy cows than in heifers (Woldu *et al.,* 2011, Juneyid *et al.,* 2017). The lack of a significant effect from different seasons may be attributed to an inadequately structured seasonal stratification, influenced by fluctuating weather patterns across different years and seasons. This is underscored by the notable significance observed in the month of insemination concerning the number of services per conception. Regardless of the non-significant results for the seasons in this study, there should be efforts to reduce environmental stress in cows after calving. Many environmental measures are correlated, and the one with the greatest impact on fertility may differ depending on geographical location (Woldu *et al.,* 2011; Tefera *et al.,* 2014). Furthermore, more research is needed to determine the range of post-breeding periods during which environmental stress negatively affects dairy cattle fertility.

As shown in Table 5, the proportion of

inseminations per conception rate tended to remain constant across various parities, seasons, and times of insemination in the current study. Table 3 shows that the conception rate after first insemination ranges between 40 and 46% based on the three factors (parity, time, and season of insemination). This lies within the range of 40% to 70% of majority of herds in USA that were reported to have heifer conception rates in this range (Wathes *et al.,* 2014; Mekonnen and Berhe, 2023). One of the possible explanations for lower proportions of cows conceiving at

Table 4: Effect of different factors on the number of services per conception in Sahiwal x Friesian Crossbred Cattle

Factor	Number of services per conception Mean±SE	P Value	Factor	Number of services per conception Mean±SE	P Value
1. Parity		<.0001	**2. Month**		<.0001
≤1	2.07±0.04b		1	2.42±0.06a	
2	2.15±0.04a		2	2.13±0.06bc	
3	2.18±0.04a		3	2.39±0.06ab	
4	2.20±0.04a		4	2.08±0.06c	
5	2.25±0.05a		5	2.19±0.06abc	
≥6	2.23±0.04a		6	2.11±0.06c	
3.	**Year**	<.0001	7	2.10±0.05c	
2000	2.27±0.09cdef		8	2.14±0.06bc	
2001	2.67±0.06ab		9	2.19±0.05abc	
2002	2.34±0.06cde		10	2.21±0.06abc	
2003	2.41±0.07bcd		11	2.13±0.06c	
2004	2.55±0.08abc		12	2.09±0.06c	
2005	1.94±0.08fgh		**4.**	**Time**	0.4341
2006	1.90±0.06fgh		AM	2.19±0.04a	
2007	1.95±0.06fgh		PM	2.17±0.02a	
2008	1.88±0.07gh		**5.**	**Season**	0.064
2009	2.84±0.07a		Dec - Feb	2.2±0.04a	
2010	2.02±0.08efgh		Mar- May	2.23±0.04a	
2011	2.04±0.1defgh		June - Aug	2.12±0.03a	
2012	1.88±0.1g		Sep - Nov	2.18±0.03a	
2013	1.25±0.12i				
2014	1.87±0.14ghi				
2015	2.23±0.09cdefg				
2016	1.52±0.17hi				
2017	2.19±0.07cdefg				
2018	2.75±0.06a				
2019	2.79±0.07a				
2020	2.41±0.07bcd				
2021	2.2584±0.11cdefg				

Means with different superscripts under the same factor are significantly different at P<=0.05

Table 5: Frequency of the number of inseminations across various parities, seasons and time of insemination

No of Insemi-nations	Parity						Seasons				Time	
	1	2	3	4	5	≥6	1	2	3	4	AM	PM
1	954 (45.5%)	873 (43.2%)	710 (41.2%)	567 (41.15)	410 (40.47)	559 (42.03)	927 (41.72)	898 (41.46)	1184 (46.30)	1064 (41.22)	802 (44.28)	3271 (42.40)
2	536 (25.58)	488 (24.13)	421 (24.94)	343 (24.89)	245 (24.19)	309 (23.23)	564 (25.38)	541 (24.98)	609 (23.82)	628 (24.33)	449 (24.79)	1893 (24.54)
3	271 (12.94)	259 (12.81)	248 (14.69)	207 (15.02)	152 (15.00)	211 (15.86)	321 (14.45)	312 (14.40)	327 (12.79)	388 (15.03)	245 (13.53)	1103 (14.30)
4	146 (6.97)	179 (8.85)	141 (8.35)	127 (9.22)	86 (8.49)	116 (8.72)	190 (8.55)	193 (8.91)	185 (7.24)	227 (8.80)	142 (7.84)	653 (8.46)
5	79 (3.77)	86 (4.25)	88 (5.21)	66 (4.79)	49 (4.84)	60 (4.51)	102 (4.59)	98 (4.52)	101 (3.95)	127 (4.92)	73 (4.03)	355 (4.60)
6	50 (2.39)	63 (3.12)	34 (2.01)	32 (2.32)	35 (3.46)	36 (2.71)	63 (2.84)	55 (2.54)	61 (2.39)	71 (2.75)	46 (2.54)	204 (2.64)
≥7	59 (2.82)	74 (3.66)	46 (2.73)	36 (2.61)	36 (3.55)	39 (2.93)	55 (2.48)	69 (3.19)	90 (3.52)	76 (2.94)	54 (2.98)	236 (3.06)

first insemination is the difficulty in detecting estrus signs. Other factors that were precluded in this study could have a significant impact on conception rates. Inseminator, nutrition, and heat detection are examples of such factors.

This study highlights that enhancing breeding performance by addressing various factors affecting the number of services to conception could contribute to the longevity of cows and heifers. This in turn, may have a positive impact on dairy farm profitability. As a result, farmers and other dairy industry stakeholders must address all of the factors that influence conception rates in order to achieve the desired results.

Conclusions

The study demonstrates that managing appropriate bull and cow factors can lead to improved outcomes in terms of the number of services per conception. Furthermore, it is critical to ensure that other husbandry practices are well provided in order to achieve better results. More research with a proper AI recording system and veterinary herd fertility program is required to account for management and environmental variation. As a result, a sustainable extension service should be established in order to improve the management and efficiency of AI services, bridge existing gaps, and improve dairy cow reproductive performance.

Disclosure of conflict of interest

Authors have no conflict of interest to disclose.

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