# Assessment of Reproductive Performances and Sex Ratio of New Born in Cross Breed Dairy Cattle of Hawassa City, Ethiopia

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## Abstract

Reproductive performance is an essential trait of cows in dairy cattle. The effect of different factors on reproductive performances and sex ratio difference in dairy cattle were not well documented in Ethiopia. In this research, cross-sectional study was conducted from December 2021 to June 2022 in Hawassa city to assess reproductive performances and effect of breeding methods on sex ratio difference of newborn. Questionnaires and observational study were used to collect data. In this study, the mean+SE of age at first service was 17.53+0.035 with difference of relatively one month from onset of puberty. The mean number of services per conception was higher in animals breed naturally (1.87+0.056) as compared to AI (1.69+0.049). Higher conception rate of 74.26% was obtained in age group of <4years as compared to old age >6years at rate of 4.11% with statistically significant difference (P<0.05). Animals with medium level of milk production (15-20L/day) more conceived to first service 43.14% than higher milk production group (20-25L/day) with 35.59%. The presence of reproductive problems significantly affect conception rate to first service with higher conception rate of 54.47% in negative animals and 22.41% in animals with reproductive problems. Conception rate was increased with increasing number of services in both breeding types. Sex of newborn was not significantly affected by breeding methods used and difference in the study area. Generally this research found that reproductive performances and use of AI in the study area were satisfactory even though age, level of milk production and presence of reproductive health problems had significant impacts on performances. In order to sustain and improve reproductive performances age, reproductive health problems and breeding management should be considered. Therefore, reproductive health management and application of AI for genetic improvement should be well practiced to improve dairy cattle reproductive performances.

## Introduction

Reproductive performance is one of the most important concerns of the modern dairy industry worldwide [54, 3]. Improved fertility maximizes profit by decreasing culling costs and by elevating incomes from milk sales and shorter calving intervals [33]. Therefore, economics of dairy enterprise is based on the efficient and effective reproductive performance of dairy cattle [21, 35].

The most common indicators of reproductive performance are age at the first service, age at first calving, calving interval, number of services per conception (NSPC), and breeding efficiency. High rates of breeding efficiency in dairy cattle are achieved through regular calving of one viable calf per breeding cow in a year [20, 49]. Reduced breeding efficiency rates can be resulted from the long calving interval of a dairy cow which is mainly due to either low conception rate and/or high early embryonic mortality [20]. Some studies in Ethiopia indicated that, overall means age at first service for crossbred female was 30.3±4.4 months. Age at first calving was 39.3±3.25 months, NSPC was 1.8 and calving interval was 17.1±4.5 months in Sidama zone southern Ethiopia [4]. In another study, the mean age at first service, age at first calving, calving interval, days open and number of service per conception were 26.8 months, 37.4 months, 476 days, 197 days and 1.8, respectively in cross breed dairy cattle at Holleta agricultural research center [17].

In order to fulfill future needs and to be able to sustain livestock production, livestock research and its applications needs to use all emerging technologies, one of which is artificial insemination (AI) to obtain a large number of offspring from genetically superior males in addition to disease control and prevention [34, 19]. From previous studies, it has been found that AI service is weak and even declining due to inconsistent service in the smallholder livestock production systems of Ethiopia [13]. And also lack of recording scheme, wrong selection procedures and poor management with poor motivations and skills of inseminators [16, 30].

A number of factors have contributed to the reproductive performance of dairy cattle including age of animals, breed body condition, post parturient problem, milk yield [22] diseases, nutrition, housing facilities, methods of breeding and number of services per-conception [45]. Accordingly, reproductive health problems causes considerable economic loss to the dairy industry due to prolonged calving intervals [12, 5].

It was found that different animal related and other factors have an effect on reproductive performances in dairy cattle and there was variation in report of research outputs in producing replacement heifers while using different methods of breeding: AI and natural services. But, some complaint from farm owners showed as more male than female new born produced when AI is used than natural services. Moreover, the sex ratio difference between natural services and AI was not well documented in Ethiopia. Therefore, this study was conducted to assess reproductive performances and its determinant factors, and to estimate rate of conception and sex ratio produced under different methods of breeding in dairy cattle in Hawassa city administration.

**Material and Methods**

*Study area*

The study was conducted in Hawassa city, Sidama Regional sate, Southern Ethiopia. The area is situated at 275 km south of Addis Ababa at a latitude of 7°04'N and a longitude 38°31'E on the escarpment of the Great Rift Valley. The altitude ranges from 1650 to 1700 m above sea level. The mean annual rainfall and temperature are 900-1100 mm and 27°C, respectively. The total livestock population of Sidama zone is estimated to constitute 1,721,341 cattle, 228,941 goats, 457,465 sheep, 204,460 equines, 725,540 poultry and 44,492 beehives. Specifically, Hawassa city administration has 155 small to large scale dairy farms with total population of 40,163 animals (Hawassa city administration, 2021).

*Study animals and management*

There were one hundred fifty five (155) dairy cattle farms in six sub cities of Hawassa. The study animals were Holstein Fresian cross breed owned by both privates and government in Hawassa city. All

study farms were grouped under intensive dairy farming system. The sources of feed for animals include grass, crop residue, concentrates and agro industrial byproducts. The animals are given feed and water three and two times per day respectively. Treatment, vaccination and management of health problems were done by veterinarians that have employed in each sub-city. Culling in the farms was practiced as a result of aging, decreased production and reproduction as well as incurable diseases. All the farms have space for exercising for the animals. Both AI and natural service methods are used in the area for breeding.

*Study design*

A cross-sectional study was used to collect information with observational and questionnaire survey from December 2021 to June 2022. Questionnaire survey was conducted at eighty four (84) dairy farms in six sub cities of Hawassa, namely: Tula, Haykdar, Meneharia, Mehal-ketema, Tabor and Misrak.

*Data collection methods*

Semi-structured questionnaire was prepared and used to interview 84 farm owners. The questionnaire was prepared in English language and translated to Amharic language for easy understating by respondents. During the interview, the respondents included in the study were briefed about the objective of study before presenting the actual questions. Different farm records were used for collections of individual animals' related data.

In the survey, data like address of owner, breed, parity, body condition score, heat detection, time of insemination, number of services pre-conception, sex of previous newborn, average milk yield, reproductive performances indicators, management factors and reproductive health problems were included. The animals' body condition score were recorded on the scale of 1-5 based on criteria set by [55]. Age of animals was recorded per year that was collected from farm records as well as by interview of owners and individual animal examination. Further, age classified as <4, 4-6 and > 6 years. Parity number and daily milk yield/cow/day were recorded from data of the farm in addition to questioning owners.

*Sample size determination and sampling techniques*

The sample size was determined by using the formula described by Yamane, (1973) as follows.

Sample size n=N/1+N (e) $^2$, N=total population, e=allowable error (5% precision).

The total number of animals found in 155 farms of Hawassa city was 40,163. Therefore sample size was calculated as 396 animals; but 409 animals' data were collected to represent all farms proportionally. In individual animal selection, sampling was done proportionally in which female cows that previously have at least one parity and having calves with the age of less than six months to collect clear data in determining sex of newborn. Therefore, 2-6 animals were sampled proportionally based on herd size from selected farm.

All owners of selected farms were interviewed for questionnaire data collections. For this sample size were calculated by using the formula given by [15] which is = 0.25/SE2, Where: N= sample size, SE (standard error) = 5%. Therefore, by using the above formula, the sample size was calculated as 100 farm owners to be interviewed. However, based on owners interest and easy of accessibility with available time and resources, only 84 farms out of 155 were examined for this study.

*Data analysis*

All data were entered in to Ms-Excel spread sheet, coded and analyzed using STATA version 12. The data were summarized using descriptive statistics of percentage and mean to determine status of

reproductive performances in the study area. The variation between different factors and its effect on rate of conception after services was analyzed by using Chi-square test ($\chi^2$) and odd ratio (OR) with confidence level of 95%, whereas $P < 0.05$ were considered for significant value.

### Results

Reproductive performances of dairy cows in the current study was evaluated by age at onset of puberty, age at first service, post-partum period, calving interval and number of service per conception (NSPC) (Table 1). This research indicated that the mean age at first services of study animals was 17.53+0.035 with difference of relatively one month from onset of puberty. The postpartum period/days was more than standard with mean +SE of 84.35+0.819. The NSPC was higher in animals breed naturally (1.87+0.056) as compared to using AI (1.69+0.049).

Table 1. Mean reproductive performances of cross breed dairy cows in Hawassa city

| Indicators | No. of examined | Mean $\pm$ SE | Min | Max | 95% CI |
|---|---|---|---|---|---|
| Age at onset of puberty / months | 409 | 16.67+0.036 | 15 | 25 | 16.601-16.744 |
| Age at first service /months | 409 | 17.53+0.035 | 16 | 27 | 17.457-17.594 |
| Postpartum period/days | 409 | 84.35+0.819 | 60 | 120 | 82.741-85.963 |
| Calving Interval /months | 381 | 12.88+0.046 | 12 | 24 | 12.792-12.972 |
| NSPC with AI | 204 | 1.69+0.049 | 1 | 3 | 1.595-1.788 |
| NSPC with NS | 205 | 1.87+0.056 | 1 | 4 | 1.763-1.983 |

NSPC=Number of services per conceptions, SE=standard error

In the result of this study, the relationship between animal related factors (such as age, parity, BCS, average milk yield per day, previous history of reproductive health problems as well as methods of breeding) with conception to first service was assessed. Accordingly, age, parity and history of reproductive health problems were significantly ($P<0.05$) affect the conception to the first service, whereas BCS, average daily milk yield and breeding mothods have non-significant effect on conception to first service ($p>0.05$). Conception to first service was decreasing with increasing age of animals significantly. Female cows with parity 2 and 3 have more success rate as compared to parity 1 (Table 2). Animals with reproductive health problems were significantly affected ($P=0.001$) in conception to first service than animals with absence of previous history of reproductive health problems.

Table 2. Factors affecting first services per conceptions

| Factors | Number examined | Number conceived | Percentage (%) | OR | p-value | 95% CI |
|---|---|---|---|---|---|---|
| **Age/year** | | | | | | |
| <4 | 101 | 75 | 74.26 | - | - | - |
| 4-6 | 235 | 89 | 37.87 | 0.0035 | 0.001 | 0.00083- 0.01456 |
| >6 | 73 | 3 | 4.11 | 0.00001 | 0.001 | 0.000013-0.00011 |

| Parity | | | | | | |
|---|---|---|---|---|---|---|
| 1 | 34 | 10 | 29.41 | - | - | - |
| 2 | 223 | 80 | 35.87 | 79.640 | 0.001 | 17.054-371.914 |
| 3 | 148 | 76 | 51.35 | 6937.57 | 0.001 | 1070.09-44977.5 |
| 4 | 4 | 1 | 25 | 136476.9 | 0.001 | 4306.95-4324624 |
| **BCS** | | | | | | |
| ≤2 | 147 | 50 | 34.01 | - | - | - |
| 3 | 258 | 115 | 44.57 | 1.699 | 0.190 | 0.769- 3.754 |
| ≥4 | 4 | 2 | 50 | 0.8278 | 0.910 | 0.032- 21.69 |
| **Average milk yield/day/Liter** | | | | | | |
| 5-10 | 17 | 6 | 35.29 | - | - | - |
| 10-15 | 78 | 30 | 38.46 | 6.699 | 0.030 | 1.199- 37.421 |
| 15-20 | 255 | 110 | 43.14 | 8.146 | 0.011 | 1.612- 41.179 |
| 20-25 | 59 | 21 | 35.59 | 5.335 | 0.075 | 0.846-33.634 |
| **Methods of Breeding** | | | | | | |
| AI | 204 | 91 | 44.61 | - | - | - |
| NS | 205 | 76 | 37.07 | 0.6334 | 0.199 | 0.316-1.271 |
| **Previous history of reproductive health problem** | | | | | | |
| Negative | 235 | 128 | 54.47 | - | - | - |
| Positive | 174 | 39 | 22.41 | 0.2415 | 0.001 | 0.156-0.375 |

Age and parity of animals showed strong relationship with NSPC. An increase in age of animal in year cause increase NSPC significantly with odds of 1.39. Similarly, the NSPC increases as number of party increases with odds 0.56. (Table 3).

| Table 3. Effect of Animal related factors on number of services per conception | | | | | |
|---|---|---|---|---|---|
| Factors | No. examined | OR | SE | P-value | 95% CI |
| Age | 409 | 1.39097 | 0.0290098 | 0.001 | 1.33525-1.449007 |
| Parity | 409 | 0.5687712 | 0.0207298 | 0.001 | 0.5295588-0.6108872 |
| BCS | 409 | 0.9290172 | 0.0309773 | 0.027 | 0.8702442-0.9917595 |
| average milk yield/ day | 409 | 0.9988624 | 0.0053838 | 0.833 | 0.98836-1.00947 |
| age at First services/ Month | 409 | 1.019821 | 0.0207437 | 0.335 | 0.9799638-1.061299 |

The percentage of animals conceived to the first service differs among different sub-cities. However there is no significant difference (P>0.05). Mehal-ketema and Meneharia sub-cities showed higher conception rate as compared to others (Figure 1). From the figure the lower conception rate to first service in Misrak and Tula (Figure. 1a) resulted in higher number of service per conception with in the same sub-cities (Figure. 1b).

Figure 1. Effect of study area on first services per conception and NSPC



a) Conception rate to first service across sub-cities

b) Average NSPC across study sub-cities
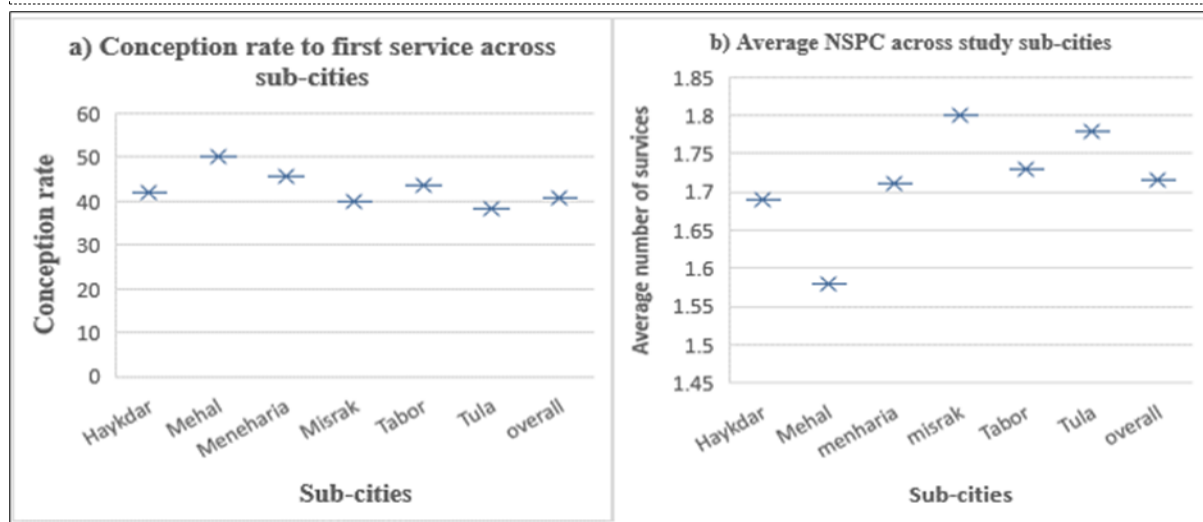
This study indicated, the rate of conception was increased with increasing number of services in both natural services and AI. Higher conception rate to first services of 44.61% were reported when AI used than natural services with 37.07% (Table 4).

Table 4. Effect of breeding methods on NSPC

| Methods of Breeding | No. Examined | No. Conceived | Percentage (%) |
|---|---|---|---|
| **NSPC with AI** | | | |
| 1 | 204 | 91 | 44.61 |
| 2 | 113 | 85 | 75.22 |
| 3 | 28 | 28 | 100.00 |
| **NSPC with NS** | | | |
| 1 | 205 | 76 | 37.07 |
| 2 | 129 | 83 | 64.34 |
| 3 | 46 | 42 | 91.30 |
| 4 | 4 | 2 | 100.00 |

There was no significant effect of study area and breeding methods on sex ratio of newborn calves (P>0.05). However, a slight difference in producing female newborn when a natural services used with 53.17% as compared to AI with 51.47% of female newborn were reported (Table 5).

Table 5. Sex ratio of new born among breeding methods and study areas

| No. Examined | | Sex of newborn N (%) | | $\chi^2$ | p-value |
|---|---|---|---|---|---|
| Breeding methods | | **Female** | **Male** | | |
| AI | 204 | 105(51.47%) | 99(48.53%) | 0.1185 | 0.731 |
| NS | 205 | 109(53.17%) | 96(46.83%) | | |
| Sub city | | | | | |
| Haykdar | 62 | 32(51.61%) | 30(48.39%) | | |
| Mehal-ketema | 18 | 9(50%) | 9(50%) | | |
| Meneharia | 24 | 11(45.83%) | 13(54.17%) | 0.6301 | 0.987 |
| Misrak | 5 | 3(60%) | 2(40%) | | |
| Tabor | 85 | 45(52.94%) | 40(47.06%) | | |
| Tula | 215 | 114(53.02%) | 101(46.98%) | | |

**Discussion**

In this study, reproductive performances of dairy cows were assessed in terms of age at onset of puberty, age at first service, post-partum period, calving interval and NSPC. The mean+SE of ages at onset of puberty of heifers, age at first service, post-partum period and calving interval in this study were 16.67+0.036 months, 17.53+0.035 months, 84.35+0.819 days, 12.88+0.046 months respectively. An average NSPC under AI and natural services were 1.69+0.049 and 1.87+0.056 respectively. The overall mean of age at first service is lower than the previous studies of 36.8±0.8, 24.3±8.01, 24 ±4.16 and 26.8 ± 0.34 months reported by [15, 4, 2, 17] respectively in different study areas of Ethiopia. On the other hand, the current report of age at first service was higher than the results that has been shown in previous studies in well-nourished temperate heifer that have potential to conceive at 14-15 months of age [25, 27]. The variation between current study and previous report will be due to breed differences, study area, management of animals, nutrition, environmental stress, herd size and social interactions as scientifically confirmed to affect the age at first onset of puberty in heifers [36, 43, 1]. In this study, urban dairy farming practices, cross breed animals of the study and improved management as compared to some rural areas were the major suggested factors for early onset of puberty as compared to different study areas of Ethiopia.

The postpartum period of cows assessed in this study was lower than previous study of [32] which was 141 days. The mean+SE of calving interval of cows in this study was 12.88+0.046 months which was shorter than previous studies of 21.36±3.84 [14], 13.4 ±5.1 months [41] and 14.64±2.2 [2] in different study areas of Ethiopia. On the other hand the current finding was slightly longer than 12.4 months reported by [24]. Age and parity of individual cows, as well as transition cows managements will bring difference in postpartum recovery period and further calving interval as well [31].The difference of calving interval might be due to poor heat detection skills of farmers, improper timing and techniques of breeding/service, season of insemination, breeding system, and milk yield level, nutrition and climate conditions may also affect the success of breeding/services that extend calving intervals [36, 51].

In the present study age of the cows significantly (P<0.05) affect conception to first service with high conception rate of 74.26% in animal age group of <4 years than older cows. This was fairly agreed with

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the result obtained by [29] and Mufti et al. (2010) who reported 77.8% and 72.73% respectively in similar age groups. The decline in fertility with advancing age might be due to a decrease in ovulation rate as a result of lack of gonadotropin release from the pituitary, a deterioration in the quality of eggs ovulated with subsequent fertilization, resulting in embryonic loss or uterine failure due to hormonal imbalance or deficiency [47, 11].

The rate of conception to first service was significantly (P=0.001) increased with parity number from 1-3. However, conception to the first service becomes decrease as parity increase to 4 and more which was decline from 51.35% to 25%. This is in agreement with [52] which was reported as an increased conception rate with advancing parity from 2 to 6, and then declined with more parities and [29] was reported increased conception rate significantly in both parity 2 and 3 (P≤ 0.05). The decreased conception rate in advanced parity of the cows might be due to the aforementioned factors related to age. Furthermore, an increase in parity brings reproductive problems and can also lead to serious locomotive, mammary and metabolic disorders [8].

In present study, the presence of reproductive health problems significantly affect first service to conception rate P=0.001. This might be due to the disturbance of metabolic and hormonal processes of the cow due to health problems. This problem is more prevalent when age and parity number of cows increasing that affect rate of conceptions as it was confirmed in this study. Age and parity of animals showed strong relationship with NSPC. An increase in age of animal in year cause increase NSPC significantly with odds of 1.39. Similarly, the NSPC increases as number of party increases with odds of 0.56. This was confirmed by the study of [18, 53] and [48] that reported an increase in age and parity of cows, and presence of reproductive problems affect conception rate to services and further increase number of services per-conception which resulted in calving-to-conception interval.

The NSPC in the present study was 1.69 for AI and 1.87 for NS. The NSPC in this study while using AI was lower than 1.95 ±0.41 [28] and 2.1 ±1.3 [30] while the NSPC with NS was higher than 1.7±0.9 [30]. Even nutritional status of animals mainly affect success in breeding, NSPC might be influenced by breeding system, estrous detection and time of insemination, environmental heat stress and health problems [50], as well as herd size, housing, level of production, age and parity [26]. In the current study area, the major practices in selecting breeding method was primarily AI for genetic improvement and only animals with suspected different health problems and repeat breading were allowed for natural services. This makes higher average number of services for individual animals during natural services than AI.

In both natural services and AI, conception rate was increased with increase in number of services. This is disagreed with studies of [10, 42] who reported that cows that were artificially inseminated several times were found to be less likely to conceive than cows inseminated once. The current study was again supported by previous study of [40]  who states that heifers and cows allocated to bulls for natural mating needed fewer services to conceive than those under AI. The difference in the current findings from previous studies might be due to limited number of bulls and high female to male ratio for natural services. In addition to this, general practices in use of natural services in the study area were done when female animals were suspected of certain reproductive problems and previous history of repeat breeding.

There was no significant difference between breeding methods (AI and NS) on sex ratio of new born (P>0.05). However, slightly more female calves (53.17%) were born with NS and 51.47% with AI. This finding agreed with previous study of [6] who was found 55.4% female calves from NS and lower when AI used. It was different from the reports which states, there is a greater probability of male calves being

born when conceived through AI [56, 7, 46]. This difference might be due to time of insemination with regard to estrous onset. In the present study area, AI was given early after onset of behavioral estrus that will give probability to have female newborn. Therefore, AI given early or late relative to time of ovulation changes sex ratio as late insemination gives chance to have male and early insemination to have female newborns. Sex ratio has no significant difference among study sites (sub-cities). However, slight difference in percentage might be due to overall management and breeding time difference.

## Conclusion

The final goal of each dairy farm is to have lower age at which puberty onset and first service, decreased number of services per conception and shorter calving interval to improve reproductive performances of the farm. According to the result of this study the overall mean reproductive performance of cross bred dairy cows was satisfactory relative to the standard. Slightly more number of services per conceptions was required when natural breeding used than AI due to animals selectively allowed for natural services when there was certain reproductive problems. Age, parity and previous history of reproductive health problems were significantly affect conception to first service. The number of services per conception was increasing with age and number of parity, or presence of reproductive problems. Sex ratio of newborn were not significantly affected by breeding methods used (natural services or AI) which need to look the advantage of AI for genetic improvement. Therefore, reproductive health management and application of AI for genetic improvement should be well practiced to improve dairy cattle reproductive performances.

## Acknowledgements

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