Research Article

Assessment on reproductive performance of crossbred dairy cows selected as recipient for embryo transfer in urban set up bishoftu, Central Ethiopia

Yonas Getachew[1], Alemayehu Lemma[1] and Haben Fesseha[2]*

[1]College of Veterinary Medicine, Addis Ababa University, PO Box 34, Bishoftu, Ethiopia

[2]School of Veterinary Medicine, Wolaita Sodo University, P.O Box 138, Wolaita Sodo, Ethiopia

Abstract

The reproductive status of a recipient cow is among the factors that influence the success of embryo transfer in bovine. The study was carried out on a total of 276 cows from 25 dairy farms classified as large (>20 cows), medium (10-20 cows) and small scale (1-10 cows) dairy production system. Data were collected through personal interviews of owners, from an individual animal record and gynecological evaluation of animals. Accordingly, the overall mean (±SD) of AFC, CI, LL, DMY, and NSPC were 30.07±2.17 months, 13.33±2.84 months, 9.08±1.10 months, 14.33±4.59 liters/day and 1.59±1.02, respectively. Milk yield and body condition did not have a significant effect on NSPC (P > 0.05) whereas parity significantly influenced NSPC, with cows in parity 3 showing the lowest NSPC (p<0.05). Farm size significantly influenced AFC, NSPC, and DMY (p<0.05). Milk yield was highly associated with increasing parity number. There was no statistically significant difference in NSPC between the breeding method (AI and NS) (P > 0.05). In conclusion, most of the reproductive parameters of the present population were within the range, however, some of the reproductive indices tended to be influenced by the scale of production. Findings of this study highlight that the selection of embryo recipient cows in the small and medium-sized farms should be meticulous considering the important indices particularly NSPC. Besides, feeding management, as shown by the body condition has been another parameter requiring consideration, particularly in small scale production.

Abbreviations

AFC: Age First Calving; AI: Artificial Insemination; CI: Calving Interval; DMY: Daily Milk Yield; LL: Lactation Length; MOET: Multiple Ovulation and Embryo Transfer; NS: Natural Service; NSC: Number of Services per Conception

Introduction

Ethiopia is a home for many livestock species and suitable for livestock production owning the largest livestock population in Africa, which has been estimated at 54 million heads of cattle, 25.5 million sheep, and 24.06 million goats. From the total cattle population, indigenous breeds are accounted for about 99.2%, while the hybrids and highly productive exotic breeds were represented by only 0.64% and 0.1%, respectively. Livestock production is one of the fastest–growing agricultural subsectors in developing countries, where it accounts for more than a third of the agricultural gross domestic product (GDP). Livestock production is expected to grow tremendously in line with the projected demand for animal products. Therefore, the methods of livestock production must change to allow for efficiency and improvement in productivity [1,2].

Cattle contribute to about 83 % of the total volume of milk produced in Ethiopia followed by goats and camels. Estimates indicated that about 97% of the country's total annual milk production is contributed by indigenous breeds [3]. Despite the huge livestock population the country holds, the per capita consumption of milk is estimated to be only 20 kg/year

as compared to 27 kg for other African countries and 100kg for the world [4]. Considering the important prospective for smallholder income generation and employment opportunities from the high-value dairy products, the development of the dairy sector can contribute immensely to poverty alleviation and improved nutrition in the country [5].

Reproduction is the backbone of animal production and productivity is the key to development. Reproductive inefficiency is one of the most important causes of economic losses in animal industries and it is realized throughout the world. Despite the remarkable advancement that has been made in the field of reproductive physiology in recent years, infertility due to low conception rate and high embryonic mortality rate remains a major problem [6,7]. To meet future needs and to be able to sustain agricultural production, agricultural research and its applications need to use all emerging technologies one of which is modern reproductive biotechnologies. Thus, various assisted-reproductive techniques have been developed and refied to obtain a large number of offspring from genetically superior animals or obtain offspring from infertile (or subfertile) animals in addition to disease control [8,9].

The reproductive performance of the breeding female is probably the single most important factor that is a prerequisite for a sustainable dairy production system and influencing productivity. Especially, the economics of dairy enterprise is based on the efficient reproductive performance of dairy animals [2,10]. The most common indices of reproductive performance are age at the first service, age at first calving, calving interval, number of services per conception, and breeding efficiency. Maximum rates of breeding efficiency in dairy cattle are attained through regular calving of one viable offspring per breeding cow in the herd in a year. Lowered breeding efficiency rates can be due to the long calving interval of a dairy cow which is mainly due either to low conception rate and/or high early embryonic mortality [11].

Poor reproductive performance results in excessively late age at first calving and long lactations. Both are costly to the dairy producers because of the veterinarian breeding expense, high reproductive replacement costs, and fewer calves being born [12]. Low reproductive efficiency due either to delayed first service, missed estrus, or multiple services per-conception continues to be a major problem in dairy herds. Several reports have indicated that poor reproductive performance, manifested as prolonged calving intervals, can result in reduced milk yield and increased culling rates and replacement cost. Such animals are not suitable for application reproductive biotechnology [13].

Reproductive biotechnologies intend to be used routinely to shorten generational intervals and to propagate genetic material among breeding animal populations. To achieve this goal, reproductive technologies have been developed in generations over the years, namely artifiial insemination (AI), embryo transfer (ET), manipulation of fertilization in vitro (IVF), cloning and transgenesis [9,14]. These, together with sperm separation techniques, including that of selection of spermatozoa for chromosomal sex (commonly named sex-sorting) all face today a strong wave of increasing commercialization [15].

Bovine embryo transfer technology involves the selection and management, both physical and pharmacological, of donor and recipient animals, and the collection and transfer of embryos within a narrow window of time following estrus. Ideally, the transfer of embryos in the cow will result in a high pregnancy rate provided that estrus in the donor and recipient occurred within 24 hr of each other. This requires the cycling of each recipient and good reproductive performance, which in turn is influenced by various management factors, to successfully result in a live offspring at the end of the embryo transfer. This technology has been incorporated into large dairy and beef cattle operations and often requires the participation of herd veterinarians. Embryo transfer is one step in the process of removing one or more embryos from the reproductive tract of a donor female and transferring them to one or more recipient females [2,16].

Recipient selection is one of the first objectives for an embryo transfer program to achieve. Although heifers used as recipients are common practice in many places, it does come with its perils. These animals typically will give higher pregnancy rates than cows, ranging from 10% to 23%. The downside is that this animal is used to carry genetics that typically is not selected for calving ease. Calving management has to be a primary concern when using heifers as recipients. Advanced parity dairy cows from 3 to 8 years of age are the optimum recipients with better milk production, better reproductive history, and better colostrum which can be selected for disposition [17].

Several types of research have been conducted to evaluate the reproductive performance of crossbreds especially for different exotic blood levels crossbred of dairy cows under a relatively controlled condition at research centers, government-owned farms [18]. However, few indicate that these animals are suitable for the application of MOET. Thus, the study was conducted to assess and compare the reproductive performance of crossbred recipient dairy cows selected for embryo transfer based on the scale of the production system and selected parameter.

Materials and methods

Study area

The study was conducted in the Oromia regional state in Bishoftu town from December 2016 to May 2017. Bishoftu is located 45 km southeast of the capital city Addis Ababa in the Ethiopian highlands (Figure 1). The area is located at 9º N latitude and 40º E longitudes. The altitude is about 1880meters above sea level. The average annual rainfall is 866 mm with a bimodal distribution. The long rainy season extends from June to September (of which 84% of the rain is expected) followed by a dry season from October to February. The short rainy season lasts from March to May. The mean annual minimum and maximum temperatures are 14ºC and 26ºC, respectively. The humidity of the study area is 66% in summer and 56% in winter [1,19].
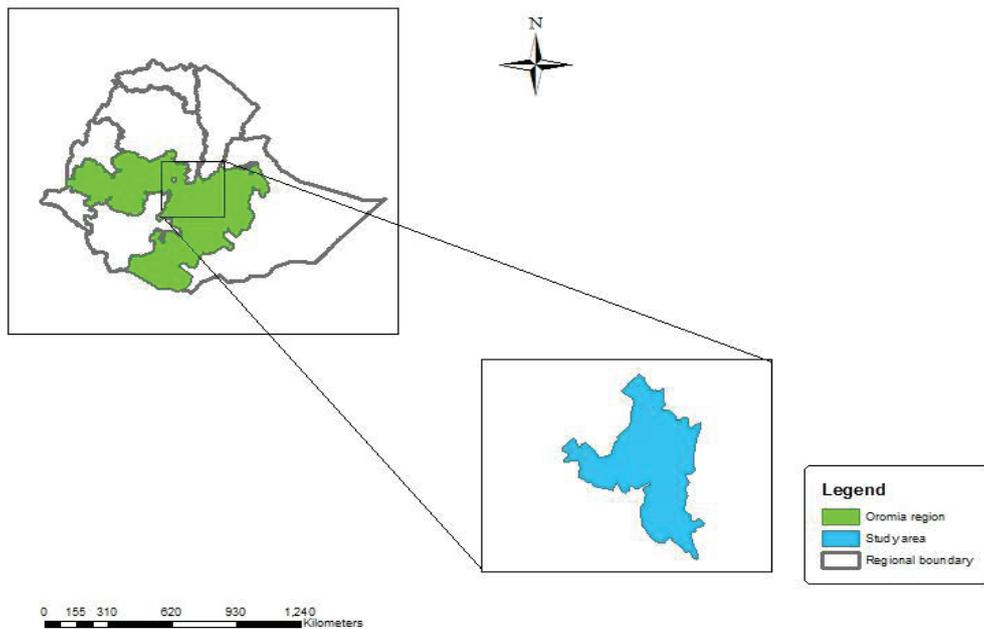
Figure 1: Map of Bishoftu town, East Shoa Zone, Ethiopia. *Source*: [19].

Study animals

This study was conducted on crossbred dairy cows belonging to large (≥20 cows), medium (11-20), and small farms (≤10) owned by dairy farmers in Bishoftu town. The majority of dairy producers in the town are market-oriented smallholder dairy farmers which are organized under one dairy cooperative called, Ada'a milk and milk products marketing cooperative share company. There are also few governmental and privately owned large (commercial) scale dairy farms with a milking herd size of over 50.

Feeding basically constituted hay, straw, and concentrate mainly from spent grain, silage, and poultry manure. Water was given *ad libitum* in all farms. Vaccination is practiced in medium and large farms for common diseases including FMD and Anthrax, Blackleg, Contagious Bovine Pleuropneumonia, Pasteurellosis, Lumpy skin disease. Breeding in all farms was using either natural or artificial insemination mostly from bulls of exotic blood. Housing conditions were mostly similar among all dairy farms with concrete floor and tie-stall system. Some of the larger farms have either a waste disposal system or produce biogas.

Study design and methodology

All the dairy owners were invited for a day workshop for discussion on the application and benefit of assisted reproductive technology particularly Multiple Ovulation and Embryo Transfer (MOET). They were explained on the MOET procedure, what constituted a recipient population, and their consent or willingness to participate in the project for embryo transfer to allow their animals as recipients were considered during the selection of the farms. Subsequently, a cross-sectional study and retrospective data analysis were conducted to study the reproductive performance of crossbred recipient dairy cows selected for the MOET program in an urban setup.

Sample size determination

The selection of the farms was purposive based on herd location, use of AI for breeding, presence of proper housing, fulfilling minimum hygienic requirements, and presence of a good recording system. Consequently, a list of 85 dairy farms was taken from the Bishoftu town agricultural information desk and then 25 dairy farms were selected based on criteria above. The farms were then classified according to their herd size into small farms (1-10 animals), medium farms (11-20 animals), and large farms > 20 animals. Accordingly, 14 were small, 5 were medium and 6 were large farms. The number of dairy cows (sample size) was determined according to the formula given by Arsham [20], as per the formula:

$$N = 0.25/SE^2$$

Where N= Sample size, SE= Standard error

Therefore, using standard error of 3% with a 95% confidence level a total of 276 animals were selected for the study.

Method of data collection

All animals included in this study were registered in a data collection sheet based on their Identification number (ID) which is written on their ear tags, those animals which do not have ear tags their name was used as identity number. Data were collected through personal interviews and recorded data. All information about individual cows such as age, parity, age at first calving (AFC), calving interval (CI), number of services per conception (NSPC), Lactation length (LL) and daily milk yield (DMY) were collected from an individual animal record and recorded on a pre-designed data collection format. Farm hygiene was rated based on 4 scale farm hygiene score-card (1 very good to 4 very poor). The Body condition score of the selected cross-bred dairy cows (BCs) were recorded according

to the method described in Garnsworthy and Pryce, et al. [21,22].

Data management and analysis

All data were entered into the Microsoft-Excel spreadsheet 2013 and analyzed using IBM Statistical Package for the Social Sciences (SPSS) Version 20. Descriptive statistics (means and proportions) were computed for all variables. Proportions were compared using mean and standard deviation. Effect of farm size, BCS, MY, and LL on reproductive indices were computed using factorial Analysis of variance (ANOVA) and General Linear Model (GLM). Because of inconsistencies in the farms' record, percent of the exotic gene was not included in the model. p-values <0.05 were considered as showing a significant difference between variables.

Ethical consideration

Ethical consideration was requested before starting the research by explaining the purpose of this study and the possible management planned to reduce pain and suffering of animal during sampling was submitted to Addis Ababa University College of Veterinary Medicine and Agriculture Minutes of Animal Research Ethics and Review committee. Approval was given by the committee after evaluation the importance of this study through different aspect since there was no ethical problem on the objectives and methodology of the proposal and authorized to implement the research project in the field work.

Results

The overall reproductive performance of selected cross-bred dairy cows

According to the current assessment, Feeding mainly constituted roughage (100%), concentrate (62.4%), poultry manure (20.9%), and silage (5.4%). Feeding a concentrate have significantly (p<0.05) influence age at first calving (AFC) The mean age for those feeding concentrates was 30.01±2.11 months and for those not feeding 31.2±2.80 months. The descriptive statistics of age, BCS, hygiene score, and reproductive performance for the different farm sizes were given in (Table 1).

Reproductive performance of selected crossbred dairy cows based on the scale of production

The reproductive performance of selected crossbred dairy cows based on the scale of production was assessed in different farm types. The selected crossbred dairy cows fall into two categories of BCS that influenced the distribution of service per conception. Based on the current finding, the AFC, CI, and NSPC were higher in small-scale dairy farms whereas LL and DMY were higher in large-scale dairy farms. The milk yield and BCS did not have a significant effect on NSPC (P > 0.05). Parity significantly (p<0.05) influenced NSPC especially with cows in parity 3 showing the lowest NSPC. The mean Age at First Calving (AFC), CI, NSPC, LL, DMY, in large, medium, and small farms was given in Table 2.

Association of milk yield and lactation length with parity number

As indicated in Figure 2, the milk yield of the cross-bred dairy cows was increased as the number of parity increases. Thus, the milk yield was highly associated with increasing parity. Moreover, the number of farm size significantly influenced AFC, NSPC, and DMY (p<0.05). However, the lactation length of the cross-bred dairy cows remains constant even though the number of parity increases (Figure 3).

The effect of mating system on the number of services per conception

Furthermore, in the current study, the association of different mating systems with the number of services per conception and its effect on the reproductive performance of the selected cross-bred dairy cows. There was no statistically significant difference in NSPC between the breeding method (AI and NS) (P > 0.05). The mean value of NSPC under artificial insemination (AI), natural service (NS), and both were shown in Table 3.

Table 1: Overall descriptive of age, BCS, hygiene score, and reproductive performance cows selected for embryo transfer.

Variable	N	Means ± SD	Minimum	Maximum
Age (years)	276	4.99±1.74	2.5	10
BCS	276	2.32±0.46	2	3
Parity	276	1.87±1.01	1	5
Age at first calving (months)	276	30.07±2.17	28	36
Calving interval (months)	148	13.33±2.84	12	36
NSPC	276	1.59±1.02	1	7
Lactation length (months)	252	9.08±1.10	6	10
Daily milk yield (liters)	162	14.33±4.59	3	30
Farm hygiene score	276	2.65±0.6	1	4

Key: N=Number of the animal; BCS- Body condition score; NSPC- number of services per conception, SD-Standard Deviation.
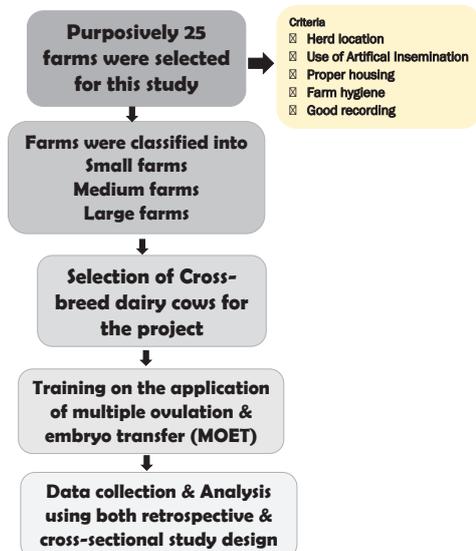
Figure 2: Flow diagram using during the study for selection of cross-breed for MOET.

Discussion

In the present study, assessment on the reproductive performance of crossbred dairy cows selected as a recipient for embryo transfer in an urban setup in Bishoftu town was conducted on 276 cows from 25 dairy farms. Out of the total farms, the mean AFC for large scale was 28.39±2.6 months and this was lower than the previous finding of Lemma and Kebede, [23] Dinka, [24] and Mureda and Zeleke, [25] who also reported between 32, 34.2 and 36.2 months for crossbred cows in different parts of Ethiopia, respectively. Other authors also indicate 58.3-36.8 months for crossbred dairy heifer at two locations in smallholder dairy farms in Zimbabwe [26] and 43.2-53.6 months for different crossbreeds in Sudan [27].

On the other hand, an analysis of over one million records indicated AFC for Holstein-Friesian heifers to be 28.1 months

Figure 3: The association of average milk yield and Lactation Length with respect to parity number.

Table 2: Descriptive statistics of reproductive performances of crossbred cows based on the scale of production in the study area.

Variable	N	Farm type	Means ± SD	Minimum	Maximum
AFC (months)	112	Large	28.39±2.6	27	33
	91	Medium	30.35±2.24	29	35
	73	Small	32.68±1.9	32	36
CI (months)	59	Large	12.71±3.4	12	28
	47	Medium	12.84±1.0	16	32
	42	Small	13.71±1.3	18	36
NSPC	98	Large	1.36±1.1	1	3
	90	Medium	1.56±1.0	1	5
	88	Small	2.37±0.8	2	7
LL (months)	130	Large	9.06±1.1	7	10
	78	Medium	7.79±1.2	6	9
	44	Small	6.28±1.0	5	9
DMY (liters)	59	Large	15.28±5.3	10	30
	52	Medium	14.13±3.4	7	23
	51	Small	13.75±4.13	3	19

Key: N=Number of the animal; AFC: Age at First Calving; CI-Calving Interval; NSPC: Number of Services Per Conception, LL-Lactation Length; DMY: Daily Milk Yield.

Table 3: The effect of mating system on the number of services per conception.

Mating system	N	Mean±SD
AI	166	1.66±0.97
Natural service	34	1.38±0.60
Both	76	1.52±1.25

(Pirlo, et al. 2000). The mean (±SD) of age at first calving for large scale farms was lower than for crossbreds dairy cows reported in Ethiopia [28-30]. In the present study, the AFC in medium-scale farms was 30.35±2.24 month and this was lower than the previous report of Wassie, et al. [30] in Bale zone of Oromia Regional State, Ethiopia (41.16±0.56 months) and Masama, et al. [26] in crossbred dairy heifers in Zimbabwe (58.3 months).

In the current study, the mean ±SD of age at first calving for small scale farms was 32.68±1.9 months. The current finding is comparable with 34.8±4 months which is reported by Dinka [24] in crossbred dairy cows in Asella and Nibret [31] in Gondar which report 32.4 months and 31.9±0.22 months, which is reported by Yifat [32] for crossbreed in Zway. The Present results were lower than the previous report of Tassew and Seifu, [33] that reports 36 months, Mureda and Zeleke [25] who reports 36.2 months and Kumar et al., [34] in Mekelle which report 36.4±17 months. However, the mean AFC in this study is higher than 26.9±5.4 months reported by Genzebu, et al. [35] for smallholder crossbred dairy cows in Bishoftu town.

The difference between the current study and previous report might be due to environmental conditions and husbandry practices which may affect body growth. These may retard growth rate, delay puberty, reduced fertility, and conception. Farm size has been indicated to significantly affect AFC in dairy animals [36]. Unlike farms using AI, farms using Natural service have a better chance of detecting estrus and getting heifers or cows pregnant at the first opportunity. Farms using AI have to go through the difficulties of estrus detection required for proper insemination which is both the number one problem in the success of AI in Ethiopia.

In this study, the mean calving Interval (CI) of the selected dairy cows was 13.33±2.84 months. A report of 13.6 months CI by Yifat, et al. [32] in Zeway for crossbreed dairy cows is comparable to the current finding. On the other hand, Dinka, [24] reported a slightly shorter CI of 12.4±0.1 months for smallholder dairy cows in Asella town. However, Sattar, et al. [37] reported a higher CI of 18.7 months than the current finding. Besides, other authors like Mureda and Zeleke [29], Fekadu et al. [38] and Hassan and Khan [39] also report higher CI from different parts of Ethiopia.

In the present finding, Calving Interval was 12.71±3.4, 12.84±1.0, and 13.71±1.3 months on Large, Medium, and Small, respectively. Mureda and Zeleke [25], reported longer CI than the present finding for small, medium, and large-sized dairy farms in Bishoftu. The variations in CI are generally attributable to differences in herd size, breeding management, nutritional conditions, management practices, and other environmental stress that could affect the animals' return to estrus, postpartum conditions, and the manifestation of estrus.

In the present study, the number of services per conception (NSPC) was 1.59±1.02 months. This was comparable with previous studies reported for tropical conditions for crossbred cows by Rahman, et al. [40] and the central highlands of Ethiopia by Shiferaw, et al. [18]. However, it was lower than
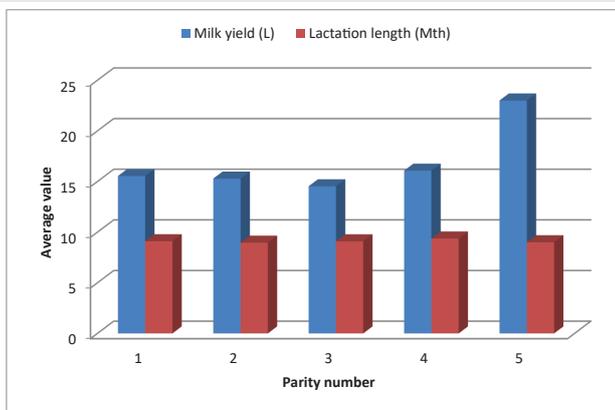
average service per conception reported for different places within Ethiopia including the highlands [10,41-43].

Besides, Nibret, [31], reported a much higher NSPC for crossbred dairy cows in urban and peri-urban areas of Gondar. Dinka, [24], also reported a higher NSPC in crossbred dairy cows in Asella compared to the present finding in both small and medium-sized farms. Reports greatly vary for NSPC ranging from 1.6 to 2.6 among authors for different farms under different production management. As herd size increases, problems with estrous detection become more important in affecting the NSPC. Further, the reproductive performance of dairy cows, semen quality, poor nutrition, reproductive disorders, improper inseminating techniques, and poor heat detection all contribute to higher NSPC.

The mean Lactation Length obtained in this study was relatively longer than compared to reported for crossbred in the Metema district [44] and North Showa (Mulugeta and Belayneh, 2013). But it was shorter than the one reported from Asella research station [45] and high-grade cows for different parts of Ethiopia [46]. This variation might be due to different factors such as breed, age, nutrition, and parity of dairy animals.

The current study indicated that Daily Milk Yield (DMY) was 14.33±4.59 liters and this was relatively higher than previous findings of Kebede [47] and Tassew and Seifu, [33] who reported that the average daily milk production of crossbred cows was 8 liters and 7.8± 0.19 liters, respectively. High yielding cows often suffer from lower reproductive performance due to the higher energy demand of production compared to reproduction. However, such a high level of production of milk has not been recorded in the present study. The difference in DMY might be due to a shortage of feed, the interaction of poor health, housing, and management.

Feeding concentrate significantly influenced the age at first calving (AFC) in the current study. This finding agrees with a previous study Heinrichs, et al. [48], who also reported that AFC was shorter in heifers fed concentrate than those fed fodder only. The influence of feeding on growth rate has been a fact in the dairy animals. Replacement heifers have to be fed in such a way that they attain at least 60% of their adult size by the time they reach puberty and 80% of their adult size by the time they calve for the first time. Parity also affected NSPC, with parity 3 showing the lowest NSPC. This is comparable to the previous report Mureda and Zeleke [29], who found that parity significantly influenced NSPC in Holstein Friesian x Zebu cross dairy cows kept in different production systems in Eastern lowland of Ethiopia.

Conclusion and recommendations

The current study population exhibited a moderate finding of reproductive performance indices which could be suitable as a first-line screening for the recipient population. Accordingly, AFC, CI, and NSPC were the most important indices of reproductive performance. Lowered breeding efficiency rates can be due to the long calving interval of a dairy cow which is mainly due either to low conception rate and/or high early embryonic mortality. The reproductive performance traits were comparatively good within large scale production and followed by medium and small-scale dairy production systems. The management condition in small-scale production has influenced the overall performance. Hence, selection recipient cows from such farms require meticulous consideration reproductive indices. In conclusion, the improvement in the reproductive and productive performance of dairy cows by improving the feeding system of the dairy cows. Also, attention should be given to heat detection, health care, timely insemination. Standard record-keeping practice on reproductive and productive traits should be established. Furthermore, the follow up of reproductive performance on dairy cows in the small-scale production is required.=

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