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An Overview of Fertility Status of Dairy Herds in Ethiopia

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Abstract

The fertility of dairy cows influences the genetic advancement of dairy herds and financial sustainability. For the benefit of the dairy industry and for the health of cows, potential strategies to increase the fertility of dairy herds are needed and should be focused on an integrative approach. This review deals with the status fertility traits such as age at first service (AFS), age at first calving (AFC), number of services per conception (SPC), Days Open(DO), and calving interval (CI) of dairy herds under Ethiopian conditions. All journal articles were cited in order to offer some information on the values of fertility status of dairy herds in Ethiopia.

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Calving intervals, days open, Fertility, Number service per conception.

Introduction

The term fertility is applied to the cow denotes the desire and ability to mate, the capacity to conceive and to nourish the embryo and finally the power to expel a normal calf and fetal membrane. Thus, fertility trait of the breeding female is probably the single most important factor that is a prerequisite for a sustainable dairy production system and influencing productivity. The fertility of dairy cows affects the genetic improvement and financial sustainability of dairy herds.

Historically, the use of conventional animal breeding techniques for the genetic enhancement of dairy cattle to increase the productivity of local breeds exceeds six decades (Leakey, 2009). Genetic upgrading programs have been launched to improve dairy cattle to increase the milk production of local breeds by importing pure temperate breed of cows to combine gene or blood level of the two genotypes.

Reproductive performance is a measure of the speed at which cows get pregnant after the voluntary waiting period. It is one of the major factors that affect the productivity and profitability of a dairy herd. The production of milk and reproductive stock is not possible unless the cow reproduces. Reproductive performance is calculated as the number of cows that got pregnant divided by the number of cows that were eligible to get pregnant.

The dairy industry's ultimate goal is to run a cost-effective operation, which is determined by the cows' reproductive efficiency. In many animal production systems, reproductive performance is biologically critical and essential for profitability. The reproductive efficiency of a herd is an important factor in the global productivity of dairy cattle. The cost of a longer calving interval, higher insemination costs, lower returns from calves born, and forced replacements in the event of culling can all be due to poor fertility. Dairy cattle breed productivity is primarily determined by their reproductive success. The AFS, AFC, NSC, DO, and CI are important fertility traits that are crucial to evaluating the feasibility of dairy production (Hammoud *et al.*, 2010; Tadele and Nibret, 2014).

This review paper enables researchers in better understanding the status of dairy herds fertility parameters in Ethiopia. It also helps policymakers in making informed decisions in order to improve the fertility of dairy cattle. Therefore, the objectives of this review paper are to highlight the overall aspects of fertility parameters.

Literature Review

Age at first service (AFS)

AFS is the age at which heifers attain body condition and sexual maturity for accepting service for the first time. It includes the period from the birth of heifer to the first insemination. The time between the birth of a heifer and the first service at the age when the animal has reached breeding maturity and is capable of normal gravidity is known as the age at first effective service. Age at first effective service is one of the most essential fertility properties in dairy cattle. Age at first effective service is determined within defined time limits. Bottom limit is date of birth, and top limit date of conception (Novakovic *et al.*, 2017). AFS signals for the beginning of heifer's performance influences both the productivity and reproductive life of the female and then influences her lifetime calf crop.

Age at first service of heifers could be attributed to factor such as breeds or level exotic blood which have influence oestrus cycle and the time of mating the heifers. Bos taurus or exotic breed heifers expected to exhibit fast growth and attain higher weights at relatively younger ages whereas Bos indicus or indigenous heifers exhibit slow growth and not attain required weights at relatively younger ages.The average age at puberty ranges from 8 to 10months for European-type dairy cows and 17-27 months for Zebu dairy cows (Novakovic *et al.*, 2017).

The period in which heifers were born have impact on age at first service. Poor feeding and management have been the reason for longest age at first service in earlier period because a majority of farmers at that time had no experience in dairy cattle management practices and dairy technologies utilization.In the tropics, authors documented different impacts of season and year on the AFS trait. The season was not affected, but the year of calving had a considerable impact (Gebeyehu *et al.*, 2005 and Berhanu and Chakravarty, 2014). On the other hand, Mengistu *et al.*, (2016) found that season has a substantial impact on AFS.

AFS also significantly influenced by the seasons in which the heifers were born. Differences in age at first service between seasons might have been attributed to seasonal fluctuations in quality and quantity of forage or pasture and other supplementary feeds availability. Calves born during the dry season tended to have highest age at first service while those born during the long rain season had the lowest age at first service. In appropriate feed supply and differences in management systems may bring variations in age at first service in different areas (Gebeyehu *et al.*, 2005).

Age at first calving (AFC)

Age at first calving is the age at which heifers calve for the first time. The beginning of a productive life of the heifer is called age at first calving. It is the period between birth and first calving. Age at first calving is closely related to the rearing intensity and has an impact on generation interval and response to selection in a breeding program. It influences the cow productive and reproductive life, both directly and indirectly, through its effect on her lifetime calf crop and milk production, as well as the cost of upbringing (Hammoud *et al.*, 2010; Gebrekidan *et al.*, 2012).

When a heifer reaches the age of first calving, it turns from a non-producing costly item into an income-generating cow. Heifers are usually mated when they are mature enough to withstand the stress of parturition and lactation in a controlled breeding system. It is recommended that heifers calve between 23 and 25 months of age, which is considered as optimum that increase profitability of the dairy business (Hammoud *et al.*, 2010).

Age at first calving of heifers could be attributed to factors such as breeds which have influence oestrus cycle and the time of mating the heifers. The prolonged age at first calving of Bos indicus heifers could be attributed to factors such as poor nutrition and management practices including poor heat detection at the time of mating the heifers. With good nutrition it is expected that Bos indicus heifers would exhibit fast growth and attain higher weights at relatively younger ages.

The period in which heifers were born have a significant on age at first calving. Poor feeding and management have been the reason for highest age at first calving during earlier period since a majority of farmers at that time had no experience in dairy cattle management practices and dairy technologies utilization.

AFC also significantly influenced by the seasons in which the heifers were born. Differences in age at first service between seasons might have been attributed to seasonal fluctuations in quality and quantity of forage or pasture and other supplementary feeds availability. Calves born during the dry season tended to have highest age at first service while those born during the long rain season had the lowest age at first service. The estimated mean of age at first service and age at first calving of dairy herds in Ethiopia reported by different scholars were summarized in the Table 1.

Calving intervals (CI)

Calving interval is the interval between consecutive calving. The gap between two successive calving is called the calving interval (Mulugeta and Belayeneh, 2013).It is a function of days open and gestation length. Since gestation length is more or less constant for a given breed, the number of days open becomes the sole variable of calving interval. A calving interval of 12 months is considered ideal assuming an average gestation period of 280 days, nearly 85 days would remain for post-calving conception to occur. Calving interval is an important factor in measuring breeding efficiency and directly correlates with the economics of milk production. Reproduction in dairy cows with regular and shorter calving intervals (365-420 days) is a key feature for the rapid multiplication of the breeding stocks.

Breeds or level of exotic breed of dairy cows are source of variation in calving interval. Bos indicus dairy cows had a mean calving interval of longer compared to Bos taurus or exotic breed cows. High-grade dairy cows have longer calved intervals than the F_1 crosses. F_2 crosses had a longer calving interval than F_1 crosses (Million *et al.*, 2006). Calving interval (CI) was shorter for Jersey crosses compared to Friesian crosses (Demeke, 2004) indicating the superiority of Jersey crosses over Friesian crosses in terms of adaptation to the local condition.Such a differences could cause by failure of farmers to detect heat signs after calving thus prolonging the interval and also associated with low nutritional status of the cows, which did not allow them to recuperate fast enough after calving.

Year effect on calving intervals in the tropics has been reported to be indirect due to dynamic climatic changes which are frequently associated with forage fluctuations, disease pattern and changes in management by farmers across the years.

Parity have impact on the calving interval trait. As parities in dairy cows increases calving intervals decreases. This could be associated with improvement in reproductive management and it also indicates that physiological maturity is attained with advanced age of cows. Previous studies revealed that the predicted mean of calving intervals for dairy herds done with different genetic groups both on station and on farm in Ethiopia are presented in Table 2.

Days open (DO)

Days open refers to the interval from calving to conception i.e., the number of days between parturition and the insemination that resulted in a pregnancy. Calving to conception interval or days open is the number of days between calving to conception and influences the profitability of the dairy industry. Days open should not exceed 80 to 85 days if a calving interval of 12 months is to be achieved. This requires the re-establishment of ovarian activity soon after calving and high conception rates.

Breeds or Level of exotic blood is source of variation for days open. The Bos indicus dairy cows had longer days open than Bos taurus or exotic breeds. The high-grade heifers had longer days open than F_1 crosses. This variation between breeds or level of exotic blood associated to production and productivity of animals, high producing animals have shorter time to return to their reproduction. It also influenced by the length of time for the uterus to completely involutes, resumption of the normal ovarian cycle, the occurrence of silent ovulation, the accuracy of heat detection, management, semen quality, and skill of inseminator or efficiency of bull (Melku *et al.*, 2011).

Table.1 Age at first service and age at first calving of dairy cows in Ethiopia

Breed	AFS (Months)	AFC (months)	Sources
Borena	32 ± 1.4	44 ± 1.5	Aynalem*et al*. (2011)
Horro	46.79 ± 1.03	48.3	Sisay (2015)
Horro	48.42 ± 0.05	58.08 ± 0.07	Ayantu*et al*. (2012)
Fogera	42.24±0.05	51.4 ± 0.05	Assemu*et al*. (2016)
Ogaden	34.4 ±2.28	49.18 ± 4.43	Getinet*et al*. (2009)
HF × Arsi	33.62 ± 0.71	42.84 ± 0.84	Wassie*et al*. (2015)
HF × Borena	30.47 ± 0.85	39.49 ± 0.83	Wassie*et al*. (2015)
HF × Borena	29.30 ± 0.21	37.99 ± 0.44	Belay and Chackravarty (2014)
HF × Borena	26.80 ± 0.34	476.35 ± 3.91	Getahun*et al*. (2019)
HF × Borena	31.33 ± 0.44	41.08 ± 0.44	Mengistu *et al*. (2016)
Friesian ×Horro	33.44±0.7	43.69±0.7	Sisay (2015)
Jersey ×Horro	31.32±1.0	42.02±1.1	Sisay (2015)
Friesian ×Fogera	36.8 ± 0.8	-	Gebeyehu*et al*. (2005)
HF × Zebu (50%)	27 ± 0.7	39 ± 0.6	Haile *et al*. (2009b)
HF × Zebu (62.5%0	28 ± 1.0	41 ± 1.0	Haile *et al*. (2009b)
HF × Zebu (75%)	28 ± 0.9	40 ± 0.9	Haile *et al*. (2009b)
HF × Zebu (87.5)	28 ± 1.2	39 ± 1.3	Haile *et al*. (2009b)
F_1 Jersey	-	39.50 ± 8	Kefena*et al*. (2006a)
F_2 Jersey	-	44.07 ± 5	Kefena*et al*. (2006a)
HF × local(50%F_1)	-	35.91 ± 1.3	Million *et al*. (2006)
HF × local(50%F_2)	-	41.91 ± 1.8	Million *et al*. (2006)
HF × local(50%F_3)	-	45.60 ± 2.6	Million *et al*. (2006)
HF × local (75%F_1)	-	40.77 ± 1.2	Million *et al*. (2006)
HF × local (75%F_2)	-	45.32 ± 2.7	Million *et al*. (2006)
Jersey × local(50%F_1)	-	38.60 ± 2.5	Million *et al*. (2006)
Jersey × local (50%F_2)	-	44.43 ± 2.3	Million *et al*. (2006)
Jersey × local (50%F_3)	-	32.22 ± 3.3	Million *et al*. (2006)
Jersey × local (75% F_1)		46.91 ± 3.8	Million *et al*. (2006)
Jersey × local (75% F_2)		34.25 ± 4.6	Million *et al*. (2006)
HF × Borena (50% F_1)	27.0 ± 0.45	37.0 ± 0.47	Getahun*et al*. (2019)
HF × Borena (50% F_2)	34.8 ± 0.82	44.6 ± 0.87	Getahun*et al*. (2019)
HF × Borena (50% F_3)	33.0 ± 1.02	44.5± 1.08	Getahun*et al*. (2019)
HF × Borena (75% F_1)	31.3 ± 0.81	42.4 ± 0.85	Getahun*et al*. (2019)
HF × Borena (75% F_2)	30.2 ± 1.58	39.9± 1.66	Getahun*et al*. (2019)
HF × Local (West Shoa)	26.83± 0.54	35.87± 0.10	Megersa*et al*. (2016)
Pure local (West Shoa)	43.44± 0.08	52.35± 0.09	Megersa*et al*. (2016)
HF 50% (Walmera)	29.02±2.65	38.14±5.43	Ketema*et al*. (2018)
HF >50% (Walmera)	22.69±3.98	31.75±4.08	Ketema*et al*. (2018)
Pure Local (Walmera)	42.23±7.4	51.73 ±6.97	Ketema*et al*. (2018)
HF × Local (West Shoa)	32.11±1.23	40.79 ± 1.23	Bayissa*et al*. (2017)
Pure Local (West Shoa)	45.27±0.47	57.08 ± 0.61	Bayissa*et al*. (2017)
HF × Local (Bishoftu)	18.7 ± 3.7	27.0 ± 3.7	Dessalegn*et al*. (2016)
HF × Local (Akaki)	18.7 ± 3.5	26.9 ± 5.4	Dessalegn*et al*. (2016)

Table.2 Calving interval for dairy cows in Ethiopia

Breed	CI (months)	Sources
Borena	14.63 ±0.33	Haile *et al.* (2009b)
Horro	15.5±0.25	Million *et al.* (2006)
Fogera	21.18±0.70	Assemu*et al.* (2016)
HF × Arsi	15.85 ± 0.11	Wassie*et al.* (2015)
HF × Borena	15.88 ± 0.16	Wassie*et al.* (2015)
Borena× HF and Jersey	15.41 ± 0.29	Kefena*et al.* (2011)
Jersey × Horro	12.76±0.3	Sisay (2015)
Friesian ×Horro	13.43±0.2	Sisay (2015)
HF × Borena	13.52± 0.11	Mengistu *et al.* (2016)
HF × Borena (50%)	14.07 ± 0.33	Haile *et al.* (2009b)
HF × Zebu (62.5%)	14.87 ± 0.40	Haile *et al.* (2009b)
HF × Zebu (75%)	14.77 ± 0.37	Haile *et al.* (2009b
HF × Zebu (87.5%)	14.77 ± 0.7	Haile *et al.* (2009b
F_1 Jersey	15.3 ± 0.3	Kefena*et al.* (2006a)
F_2 Jersey	17.17 ± 0.17	Kefena*et al.* (2006a)
75% Jersey	17.60 ± 0.17	Kefena*et al.* (2006a)
HF × local(50%F_1)	14.63±0.35	Million *et al.* (2006)
HF × local(50%F_2)	14.62±0.99	Million *et al.* (2006)
HF × local(50%F_3)	15.23±0.97	Million *et al.* (2006)
HF × local(75%F_1)	15.97±0.43	Million *et al.* (2006)
HF × local (75% F_2)	14.62±0.99	Million *et al.* (2006)
Jersey × local(50%F_1)	13.90±0.54	Million *et al.* (2006)
Jersey × local(50%F_2)	16.20 ± 0.57	Million *et al.* (2006)
Jersey × local(50%F_3)	14.30 ± 2.02	Million *et al.* (2006)
Jersey × local(75%F_1)	12.38 ± 1.15	Million *et al.* (2006)
Jersey × local(75%F_1)	14.68 ± 1.71	Million *et al.* (2006)
HF × Borena (50% F_1)	15.37 ± 0.20	Getahun*et al.* (2019)
HF × Borena (50% F_2)	16.69 ± 0.46	Getahun*et al.* (2019)
HF × Borena (50% F_3)	15.73 ± 0.57	Getahun*et al.* (2019)
HF × Borena (75% F_1)	17.26 ± 0.48	Getahun*et al.* (2019)
HF × Borena (75% F_2)	12.85 ± 1.14	Getahun*et al.* (2019)
HF × Local (West Shoa)	14.59 ± 0.04	Megersa (2016)
Pure local (West Shoa)	24.63 ± 0.03	Megersa (2016)
HF 50% (Walmera)	14.48 ±1.19	Ketema*et al.* (2018)
HF > 50% (Walmera)	14.02 ±1.04	Ketema*et al.* (2018)
Pure Local (Walmera)	15.03 ±1.04	Ketema et al. (2018)
HF × Local (West Shoa)	17.69±0.86	Bayissa*et al.* (2017)
Pure local (West Shoa)	20.93 ± 0.22	Bayissa*et al.* (2017)
HF × Local (Bishoftu)	13.0±2.1	Dessalegn*et al.* (2016)
HF × Local (Akaki)	13.8±1.9	Dessalegn*et al.* (2016)

Table.3 Estimates of days open of dairy herds in Ethiopia

Breed	Days open(days)	Source
Borena	141 ± 7	Aynalem*et al.* (2011)
Horro	88.3±2.03	Sisay (2015)
Fogera	285±4.3	Menale*et al*. (2011)
HF × Arsi	193.77 ± 4.06	Wassie*et al*. (2015)
HF × Borena	195.47 ± 4.74	Wassie*et al*. (2015)
HF × Borena	134.84±3.51	Mengistu *et al.* (2016)
Friesian Cows	177	Gebeyehu (2007)
Friesian × Horro	123	Gizaw*et al*. (2011)
Jersey × Horro	109	Gizaw*et al*. (2011)
Holstein Friesian × Zebu	155	Belay *et al*. (2012)
HF × Borena (50%)	127 ± 7	Aynalem*et al.* (2011)
HF × Borena (62.5%)	135 ± 8	Aynalem*et al*. (2011)
HF × Borena (75%)	142 ± 8	Aynalem*et al.* (2011)
HF × Borena (87.5 %)	134 ± 14	Aynalem*et al*. (2011)
F_1 Friesian	173.19±5	Kefena*et al*. (2006a)
F_2 Friesian	173.5±2	Kefena*et al*. (2006a)
F_1 Jersey	162.75±4	Kefena*et al*. (2006a)
F_2 Jersey	183±2	Kefena*et al*. (2006a)
75% Friesian	169.17±3	Kefena*et al*. (2006a)
75% Jersey	168.55 ± 2	Kefena*et al*. (2006a)
HF × Borena (50% F_1)	180.82 ± 6.03	Getahun*et al*. (2019)
HF × Borena (50% F_2)	222.67 ± 13.48	Getahun*et al*. (2019)
HF × Borena (50% F_3)	192.06± 17.64	Getahun*et al*. (2019)
HF × Borena (75% F_1)	243.03 ± 14.39	Getahun*et al*. (2019)
HF × Borena (75% F_2)	108.55 ± 33.45	Getahun*et al*. (2019)
HF × Local (West Shoa)	122.4±5.2	Megersa (2016)
Pure Local (West Shoa)	216.9±2	Megersa (2016)
HF 50% (Walmera)	5.70 ±1.42	Ketema*et al*. (2018)
HF >50% (Walmera)	4.75 ±1.12	Ketema*et al*. (2018)
Pure Local (Walmera)	7.64±2.65	Ketema*et al*. (2018)
HF × Local (West Shoa)	113.08± 0.31	Bayissa*et al*. (2017)
Pure Local (West Shoa)	191.40 ± 0.35	Bayissa*et al*. (2017)

Table.4 Number of services per conception (NPC) for dairy cows in Ethiopia

Breed	NPC(No)	Sources
Arsi	2.4±0.2	Azage (2000)
Barka	1.6±0.74	Azage (2000)
Borena	2.17±0.31	Meseret*et al*. (2014)
Horro	2.00 ±0.35	Gizaw*et al*.(2011)
Fogera	1.42±0.05	Assemu*et al*. (2016)
HF× Arsi	1.39 ± 0.05	Wassie*et al* (2015)
HF × Borena	1.32 ± 0.06	Wassie*et al* (2015)
Friesian × Borena	2.4 ± 0.13	Haile*et al*. (2009b)
Friesian × Horro	1.69±0.1	Sisay (2015)
Jersey × Horro	1.75±0.1	Sisay (2015)
HF × Fogera	1.54 ± 0.1	Gebeyehu*et al*. (2005)
HF × Zebu (50%)	2.2 ± 0.10	Haile *et al*. (2009b)
HF × Zebu (62.5%)	2.7 ± 0.18	Haile *et al*. (2009b)
HF × Zebu (75%)	2.2 ± 0.17	Haile *et al*. (2009b)
HF × Zebu (87.5%)	1.7 ± 0.11	Haile *et al*. (2009b)
F_1 Jersey	1.59±4	Kefena*et al*. (2006a)
F_2 Friesian	1.4±4	Kefena*et al*. (2006a)
F_2 Jersey	1.68±4	Kefena*et al*. (2006a)
75% Friesian	1.59±5	Kefena*et al*. (2006a)
75% Jersey	1.23±2	Kefena*et al*. (2006a)
HF × Borena (50% F_1)	1.64 ± 0.04	Getahun*et al*. (2019)
HF × Borena (50% F_2)	1.79 ± 0.09	Getahun*et al*. (2019)
HF × Borena (50% F_3)	1.84 ± 0.11	Getahun*et al*. (2019)
HF × Borena (75% F_1)	1.97 ± 0.09	Getahun*et al*. (2019)
HF × Borena (75% F_1)	1.33 ± 0.19	Getahun*et al*. (2019)
HF × Local (West Shoa)	2.14± 0.09	Megersa (2016)
Pure Local (West Shoa)	3.3± 0.09	Megersa (2016)

The effects of period and season of calving on days open associated with the improvement in the reproductive management by farmers and poor-quality feeds obtained during the dry periods resulted into longer days open for cows that calved during those periods because animals take a longer time to recover after calving.The long days open in the dry season and short in the rain season expected because cows/heifers that calved during the wet season received adequate feeds in terms of quality and quantity thus could recover within a short time compared to those that calved during the long dry season where there in-adequate nutrients.

Parity have impact on the days open trait. Animals that calved in parity one had the highest mean DO follow by those in second, third and etc. This could be due to physiological stress experienced by the first calvers in early lactation. High milk yields during early lactation are suspected to increase days open, perhaps due to biological antagonism between energy balance and reproductive cycling. Estimated mean of days open for dairy herds Ethiopia reported by different scholars were summarized in Table 3.

Number of services per conception (NPC)

NSC is the number of days between the first insemination and positive pregnancy diagnosis. The number of services per conception (NSC) is the number of services (natural or artificial), required for successful conception. It is a good measure of the fertility status of dairy herds. It is reflecting the efficiency of management.

The number of inseminations required to produce a live calf is one of the most useful parameters of reproductive efficiency which mainly depends on the breeding system used. One of the most important measures of reproductive efficiency is the number of inseminations required to deliver a live calf, which is heavily depends on the breeding strategy used. Haile *et al.*, (2008) reported that values of the number of services per conception (NPC) greater than 2 should be regarded as poor.

Breeds or level of exotic blood, parity, season and period of calving have effect on the number of services per conception.Excellent herd management and performance of cows can be associated with lowest services per conception.Cows with higher milk yields are known not to breed quickly, have longer service periods and take a long time to conceive. Heifers/cows that calved during the long dry season require more services per conception, while those that calved during the long rain season had lower services per conception. Poor nutrition has often been a limiting factor to dairy cattle performance particularly in the long dry season when nutritive value of pasture is very low. Insufficiency or an imbalance of protein, energy, roughage, vitamins and minerals do result in repeat breeders as well as low ovarian activity. The predicted mean of number of services per conception for the dairy herds reported by different authors are shown are in Table 4.

Animal production often contributes a great deal to the growth of the national economy and to the improved living standards in both rural and urban areas. Ethiopia has a huge number of dairy cattle and a great potential to develop dairy products. But dairying in the country has not been completely developed and promoted.

The fertility of dairy cows influences the genetic advancement of dairy herds and financial sustainability. Fertility is a trait of economic importance in dairy production.

Reproductive performance is the one that can influence the profitability of the dairy farms in terms of increasing or decreasing milk yield, reproductive culling rate and market price of dairy cows. Number of services per conception, age at first service and calving, open days before conception and calving intervals are important fertility traits that are critical to deciding the profitability of dairy production.

Fertility is a multi-factorial trait and its deterioration was caused by a network of genetic, environmental and managerial factors and their complex interactions make it difficult to ascertain the exact reason for this decline.

Recommendation

Based on the above conclusive statements, the following recommendations are forwarded:

Continuous implementation of fertility improvement strategies like crossbreeding and selection strategies, nutritional strategies and controlling of diseases.

Training and awareness creation should be given particularly to the farmers to increase the reproductive performance of the dairy cattle through improved management practices especially in early post-partum period.

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