International Journal of Livestock Research, Vol. 12 (7) Jul' 2022
http://www.ijlr.org
eISSN: 2277-1964

Review

Review on Artificial Insemination in Dairy Sector

Habtamu Endale Tilahun*

School of Veterinary Medicine, Wolaita Sodo University, Wolaita Sodo, ETHIOPIA

*Corresponding Author: habtamuvet@gmail.com

How to cite this paper:
Tilahun, H. (2022). Review on Artificial Insemination in Dairy Sector. *International Journal of Livestock Research*, 12(7), 14-27.

Received : Apr 16, 2022
Accepted : Jul 30, 2022
Published : Jul 31, 2022

Abstract

Artificial insemination is the technique in which semen with living sperms is collected from the male bull and, processed, stored, and introduced into the female reproductive tract at the proper time with the help of instruments for the purpose of conception. This has been found to result in normal offspring. In this process, the semen is inseminated into the female animals by placing a portion of it either in collected or diluted forms into the vagina, cervix, and uterus by mechanical methods at the proper time and under most hygienic conditions. Also usually referred to as assisted reproduction technologies (ART), including in-vitro fertilization, intra-cytoplasmic sperm injection, embryo transfer, and gamete intra-fallopian transfer. The use of artificial insemination is for the genetic improvement of farm animals. It is also used for breeding dairy cattle and has made bulls of high genetic merit available to all animals in the world Ethiopia is now grown, but oestrus detection is difficult owing to poorly expressed oestrus of same breeds like zebu breeds and the success rate in Ethiopia is still low, owing to a number of technical, financial, infrastructural, and managerial and heat detection problems and the demerits are they find trained skill, taking a lot of time and practice to carry out efficiently and effectively each time. Because of this, a qualified vet or animal technician will be needed and these can be costly. And based on technique, AI was performed in three forms; they are Intravaginal, Intra cervical, and Intrauterine, however, it has a major problem associated with artificial insemination service, like, inability to detect estrus, disease, management problem, poor inseminating technique, poor semen handling and inability to control estrus cycle. Reproductive efficiency of the dairy herd is important to the economic success of the dairy operation. Thus, the efficient and accurate detection of estrus and the proper time of insemination is of utmost importance if dairy producers want to increase the reproductive efficiency of the herd.

Keywords: Artificial Insemination, Dairy, Estrus

Introduction

Ethiopia is believed to have the largest livestock population in Africa and this livestock sector has been contributing considerable portion to the economy of the country. It possesses one of the world's largest livestock populations of which >59.5million cattle population makes the country ranks first in Africa and 6th in the world, 30.7million sheep population which makes 3rd in Africa 10th in the world and 30.2million goats which makes again 3rd in Africa and 8th in the world. 2.16 million horses,8.44 million donkeys,0.41million mules,1.21million camels, and 56.53 million of poultry population that includes (cocks, cockerels, pullets, laying hens, non-laying hens, and chicks) and 5.9 million bee hives that make Ethiopia to stand1stin Africa and 9th in the World (CSA, 2017).

In spite of the presence of large and diverse animal genetic resources, the productivity or that means both milk and meat of livestock remains low in Ethiopia due to a lack of skilled manpower, lack of management program, poor genetic potential, inadequate animal health services and other cases related to the productivity of livestock (Gebremedhin, 2005).

The use of artificial insemination (AI) in Ethiopia is now grown, but oestrus detection is difficult owing to poorly expressed oestrus of the same breeds as zebu breeds (Desalegn, 2008). Cattle breeding is mostly uncontrolled in Ethiopia making genetic improvement difficult and an appropriate bull selection criterion has not yet been established and applied (Kubkomawa, 2018).

Although artificial insemination (AI) has been operated in Ethiopia for more than 30 years the efficiency and impact of these operations have not been well-documented (Alemayehu, 2010). Artificial insemination (AI) has become one of the most important techniques ever devised for the genetic improvement of farm animals. It has been most widely used for breeding dairy cattle and has made bulls of high genetic merit available to all animals (Lobago, 2007; Jodie, 2006).

Despite the wide application of artificial insemination and its success throughout the developed world, as a matter of fact, the success rate in Ethiopia is still low owing to several technical, financial, infrastructural, managerial and heat detection problems (Merga *et al*., 2010).

Therefore, the objectives of this paper are:

- To review artificial insemination in the dairy sector.
- To highlight techniques and uses of artificial insemination.

Literature Review

Definition of Artificial Insemination

Artificial insemination (AI) is the technique in which semen with living sperms is collected from the male bull and, processed, stored, and introduced into the female reproductive tract at the proper time with the help of instruments for the purpose of conception. This has been found to result in normal offspring. In this process, the semen is inseminated into the female by placing a portion of it either in collected or diluted forms into the cervix or uterus by mechanical methods at the proper time and under most hygienic conditions (Webb, 2010).

Artificial insemination is one of the technologies usually referred to as assisted reproduction technologies (ART), in which, offspring are produced by enabling the meeting of gametes (spermatozoa and oocytes). Other techniques encompassed by ART include the following: in-vitro fertilization (IVF) where fertilization takes place outside the body; intra-cytoplasmic sperm injection (ICSI) which is a single spermatozoon caught and injected into an oocyte; embryo transfer (ET) where embryos that have been derived either in-vivo or in-vitro are transferred to a recipient female to establish a pregnancy; gamete intra-fallopian transfer (GIFT) where spermatozoa are injected into the oviduct to be close to the site of fertilization in-vivo; and cryo-preservation where spermatozoa or embryos, or occasionally oocytes are cryo-preserved in liquid nitrogen for use at a later stage (Ubkomawa, 2018).

According to Tadesse, (2010) despite a large number of livestock, there has been a decline in national and per capita production of livestock and livestock products, export earnings from livestock, and per capital Consumption of food from livestock origin since 1974. The per capital consumption compared to other African countries is low due to diseases in farm livestock have always been constraints of considerable importance to farmers, due to the lack of any recording system and extensive way production, information on diseases is not well documented and the measurement of the account of infectious and noninfectious diseases in a population assists in determining their importance and the efficacy of control campaign is poor (Thrusfield, 2005).

The indigenous livestock breeds of Ethiopia have the capacity to cope with the harsh environmental conditions of the country. They often have special adaptive traits for disease resistance, heat tolerance, and the ability to use poor-quality feed which they have acquired through natural selection over one hundred of generations. They, therefore, need relatively less environmental modification to achieve increased productivity (Agaze *et al.*, 2010).

Despite this adaptation, *Bos indicus* cattle have some particular reproductive characteristics that contribute to poor reproductive efficiency. The use of artificial insemination (AI) after estrus detection may be limited in tropical areas due to the fact that *Bos indicus* cattle have a short length of oestrus behavior with a high incidence of estrus occurring during the dark hours (Filho and Vasconcelos, 2010). On the other hand, temperate livestock breeds, although they have the genetic capacity for high production, their performance in the existing environment is not that attractive and they are not viable. The focus of breed improvement in Ethiopia so far has been through the cross-breeding of the local livestock with exotic breeds (Million *et al.*, 2006).

The national artificial insemination service mainly focuses on cattle to boost milk production and uses exotic and local semen as appropriate. Exotic semen includes Friesian and Jersey, while the indigenous include Fogera, Horro, Borana, and Begait. Having recognized the importance of artificial insemination in dairy development, the government embarked on the technology on a wider scale and established the NAIC at Kaliti in 1981. The center was initially designed to accommodate 25-30 bulls at a time. Office laboratories, artificial insemination training (AITs) center, and other facilities were constructed. The center operates a semen processing laboratory and LN processing plants. From the total semen produced, the major share is from Friesian 75.3% followed by Jersey (10.5%). The National Artificial Insemination Center (NAIC) is now the only center that produces semen in the country. On average, about 120,000 doses of frozen semen and 40,000-50,000 L of liquid nitrogen (LN) are produced annually at Kaliti (Agaze *et al.*, 2010).

History of Artificial Insemination

Historically the manipulation of the reproductive processes started in the early 1930s with the development of procedures for artificial insemination. When it was feasible to deep-freeze the semen, the use of artificial insemination became widespread in 1960-70s. With the concurrent developments in reproductive research on the female reproductive process soon the procedures were developed for the induction oestrus cycle and synchronization. Initially, this was done using steroid hormones, but subsequently the same was accomplished by using prostaglandins (Sasidhara, 2006).

The first scientific research on artificial insemination of domestic animals was performed on dogs in 1780 by the Italian scientist, Lazanno Spalbanzani. The first successful artificial insemination was performed in Italy in 1780 and over 100 years later, in 1890, it was used for horse breeding (Desalegn, 2008). His experiments proved that the fertilizing power resides in the spermatozoa and not in the liquid portion of semen. Few further studies under research station conditions helped this technique to be used commercially all over the world including in India (Shehu *et al*., 2010).

Artificial insemination (AI) was the first great biotechnology applied to improve the reproduction and genetics of farm animals and it has also had an enormous impact worldwide in many species, particularly dairy cattle. The first cattle artificial insemination cooperative was started in the United States in New Jersey in 1938. The development of techniques for frozen livestock and wild animals' semen across the globe has made AI practice a reality. However, in developing countries, improvements in livestock production have generally been lacking, and one of the principals limiting factors has been the lack of genetically improved animals (Foote, 2002).

Artificial insemination is not merely a novel method of bringing about impregnation in females. Instead, it is a powerful tool mostly employed for livestock improvement. In artificial insemination, the germ plasma of the bulls of superior quality can be effectively utilized with the least regard for their location in faraway places. By adoption of artificial insemination, there would be a considerable reduction in both genital and non-genital diseases in the farm stock (Troedsson *et al*., 2001). The testing of the bulls prior to being used as semen donors is the foundation upon which the success of AI in milk production has been laid. Bull studs can almost guarantee an improvement in body type and levels of milk production in female offspring sired by AI bulls. National increases in milk production per cow is directly associated with the use of artificial insemination in dairy herds (Kubkomawa, 2018). Adequate information is lacking on the performance of AI and factors affecting its efficiency under farmers' management systems in Ethiopia (Woldu *et al*., 2011).

Artificial Insemination Techniques

Intravaginal insemination (IVI)

The vaginal *Insemination*, this method involves depositing semen deep in the vagina without any attempt to locate the cervix. Semen is deposited in the anterior vagina. Vaginal insemination using fresh diluted semen is the simplest and quickest method but requires a large semen dose (150-400 million spermatozoa per insemination), vaginal insemination using fresh semen gives acceptable calves or lambing rate. Unfortunately, the transportation and preservation of fresh semen limit its use among animal farmers. Therefore AI, using frozen-thawed semen is an alternative and acceptable option. Vaginal insemination using frozen-thawed semen gives variable calving or lambing rates; 17% (Donovan *et al*., 2004; Anel *et al*., 2005) and 67.4% (studied in 543 Norwegian crossbred animals, inseminated with 200 million spermatozoa) (Paulenz *et al*., 2005

Intracervical insemination (ICI)

Intra-cervical insemination using fresh diluted semen is commonly used in AI of animals when performed properly, cervical insemination with fresh diluted or undiluted semen results in high fertility, whereas the fertility obtained following intra-cervical insemination with frozen-thawed semen is poor (Suranaree, 2009). Intra- cervical insemination is performed by insemination at the cervical opening or at the deepest possible intra-cervical site that is easily accessible without attempting to force the inseminating pipette into the cervical canal (Ayad *et al*., 2004; King *et al*., 2004). The depth of penetration is related to the breed and age of animals (Kaabi *et al*., 2006). In older animals, the cervix is longer and wider with looser folds, allowing easier passage of an inseminating pipette. The depth of insemination has an effect on fertility and the pregnancy rate detected by ultrasonography at day 40 after insemination and calving or lambing rates increase as the depth of insemination into the cervix increases (Suranaree, 2009).

Intrauterine insemination (IUI)

Intrauterine insemination is a treatment used in couples with mild/moderate male factor, when female partner has at least one tube patent, and the use of Assisted Reproductive Technology (ART) is a highly successful methodology for the treatment of infertility. Intrauterine Insemination (IUI) is considered the simplest and least invasive procedure with reasonable live birth rates and not needing expensive infrastructure (Ombelet *et al*., 2014). Inseminations have been done in domestic and farm animals since the 1900s while human artificial inseminations began in the 1940s (Bols *et al*., 2010)

Following intercourse, the entire male ejaculate is normally deposited in the vagina. A large proportion of the sperm are immediately destroyed, a few sperm survive and swim past the cervix, into the uterus, and eventually into the fallopian tubes to fertilize the egg. IUI is a type of artificial insemination in which there is a transfer of many motile (actively swimming) sperm, through the cervix and directly into the uterus (Ombelet *et al*, 2006).

Major Problems Associated with Artificial Insemination

Inability of Oestrus Detection

Heat detection is basic to reproductive success in artificially bred dairy herds, yet estrus detection rates have decreased in recent years. Reduced heat detection success tends to be blamed on increased herd sizes and more cows per person, as well as higher milk production per cow (Lopez *et al*., 2010). Higher milk production is related to negative energy balance, which occurs when cows simply can't eat enough to replace body weight used to produce milk. Researchers have generally attributed delayed first ovulation and smaller follicle size factors contributing to reduced fertility rates to negative energy balance. Part of the negative relationship between fertility and high milk production may be genetic. However, the genetic component in cow fertility performance tends to be small (Murray, 2011). Worldwide there are reports that indicate low rates of service in artificially inseminated cattle, mainly due to problems in the detection of estrus. While few cows are detected in heat losses occur in significant herd reproductive efficiency and commitment to the artificial insemination program. This commitment is even higher in *Bos indicus* cattle, whose breeding behavior has special features of the heat of short duration with a high percentage of expression during the night (Costa *et al*., 2004).

Both conceptions per breeding and heat detection efficiency increase when milk production increases. This indicates that producers can have greater milk yield along with good reproductive performance. Effective heat detection encourages a producer to take advantage of the superior genetics available through artificial insemination (Graves, 2009). Accurate and efficient heat detection in dairy cattle is a critical component of an artificial insemination program. While it is essential for maintaining a profitable calving interval, heat detection has always been a major challenge to most dairy herd managers (das.psu.edu). A frequent question concerning AI is: What time during estrus should a cow is bred for the greatest chance of conception? Since estrus may last from 10 to 25 hours there is considerable latitude in the possible time of insemination. Maximal conception is obtained when cows are inseminated between mid-estrus and the end of standing estrus, with good results up to 6 hours after estrus. A successful heat detection program and subsequent proper timing of insemination will pay dividends in increasing reproductive efficiency (Webb, 2010).

Diseases

The other constraint like disease, of AI service, is animal health, it is challenged by a wide spectrum of diseases, which remain as one of the main constraints of livestock development in Ethiopia. Incidence of diseases such as Tuberculosis, Brucellosis, and Mastitis could increase with the introduction of grade cattle (Chebel, 2010).

Mastitis is the single most important disease affecting lactating dairy cows because of the economic losses related to lower milk yield, milk discarded, culling, and antibiotic therapy of cows. Another very important consequence of mastitis is reduced reproductive performance (Sharif *et al*., 2009). Lameness, udder health, and infertility are the major concern of animal health services in the dairy sector. The main effects of diseases include mortality, reduced production of meat and milk, decreased draught power output, lowered quality of animal products and by-products, and the risk of zoonotic diseases to human beings. The areas with predominant infectious diseases have not initiated to accept semen of improved breeds, which has affected the field of AI (Tadesse, 2010).

The venereal infection (*Vibrio fetus* and *Trichomonas foetus*) was an important factor in the problem of herd infertility in a great many countries. The incidence of these infections has been markedly reduced, particularly as a result of veterinary measures and the use of artificial insemination. In a number of countries, however, these infections continue to be important causes of diminished fertility of the cattle population (Francisco *et al*., 2015). Another infection that may cause considerable losses is *Bruceila abortus*. The infection has also been almost completely eradicated in a number of countries and, in others, animals are being vaccinated.

In those countries, however, in which standards of cattle farming are lower, considerable efforts will be required to eliminate this infection (Dobson *et al*., 2010). A large number of other infections may also give rise to abortion (leptospirosis, bovine viral diarrhea), occasionally accompanied by the retained placenta and subsequent metritis and infertility. Infectious pustular-vulvovaginitis (IPV) infections may be an incidental cause of diminished fertility. When natural service is employed, only vaginitis will occur and fertility usually does not show a decrease. When, on the other hand, semen infected with the IPV virus is introduced into the uterus, this frequently results in endometritis and a decrease in pregnancy rates. The adequate inspection of AI bulls is therefore essential (Kruif, 2005).

The effect of retained placentas on subsequent fertility is due to delayed involution of the uterus and chronic metritis, one of the more common causes of infertility. Vitamins A and D and selenium-deficient cows have high placenta retention rates (Kononoff *et al*., 2007). Repeat breeding is a substantial problem in cattle breeding leading to large economic loss for the dairy producer due to more inseminations, increased calving intervals and increased culling rates (Gustafsson and Emanuelson2002).

Management problem

Management is made up of a large number of entities that are of vital importance to fertility. The climate is an important factor in the conception of cattle. High temperatures and a high degree of humidity will result in less marked signs of oestrus and reduced conception rates. The proportion of cows in which embryonic death occurs is believed to be much higher in the tropics than it is in the more temperate zones. The manner in which the cows are housed was found to affect the pregnancy rate after the first insemination. The average rate is higher when systems are adopted in which the cows have freedom of movement than it is in tie stalls. The differences between the herds were found to have disappeared during the grazing season. Freedom of movement not only increases the intensity of the signs of oestrus but also stimulates the onset of the cycle after parturition, particularly in primiparous animals (Khalifa *et al*., 2008).

The selection of dairy cattle for milk yield has linked the endocrine and metabolic controls of nutrient balance and reproductive events so that reproduction in dairy cattle is compromised during periods of nutrient shortage, such as in early lactation. The energy costs to synthesize and secrete hormones, ovulate a follicle, and sustain an early developing embryo are probably minimal compared to the energy needs for maintenance and lactation. However, the metabolic and endocrine cues associated with negative energy balance **(**NEB**)** impair the resumption of ovulatory cycles, oocyte, and embryo quality, and establishment and maintenance of pregnancy in dairy cattle. As the demands for milk synthesis increase, reproductive functions may be depressed when no compensatory intake of nutrients is achieved (Caraviello *et al*., 2006).

Several nutritional strategies have been proposed to improve the reproduction of dairy cattle with no detrimental effect on lactation performance. Maximizing dry matter intake (DMI) during the transition period, minimizing the incidence of per parturient problems, adding supplemental fat to diets, and manipulating the fatty acid content of fat sources are expected to benefit reproduction in dairy cattle. However, factors such as high incidence of metabolic diseases early postpartum, poor body condition score at first insemination, and excessive gossypol concentrations in plasma are detrimental to the fertility of dairy cattle (Santos, 2008).

Nutritional imbalances, deficiencies, or erratic management of feeding programs for dairy cows can create large numbers and various types of health problems generally categorized as metabolic diseases. The reproductive performance of high-producing dairy cows on modern commercial farms is influenced by a multitude of factors. All aspects of these operations, including biosecurity, employee management, housing, bedding, feed delivery, manure removal, stocking density, animal restraint, heat abatement, and fresh cow management, were evaluated as predictors of animal health, milk production, reproductive efficiency, culling rate, labor efficiency, and overall owner satisfaction (Caraviello *et al*., 2006).

Moreover, compared with *Bos taurus*, *Bos indicus* cows have longer lengths of gestation and postpartum an oestrus, making it difficult to adhere to 365 days calving interval even in ranches using natural service and resulting in a large number of cows calving at end of the calving season and having less time with a chance to become pregnant during the subsequent breeding season. These challenges are more critical in primiparous cows in pasture management systems because the intake of nutrients during the postpartum period is not sufficient to meet requirements for growth as well as lactation. As a result of the poor pregnancy rates in primiparous cows, many producers maintain non-pregnant primiparous cows in their herds to be inseminated during the subsequent breeding season, which contributes to reducing the profitability of cow-calf enterprises. Besides these differences regarding the oestrus behavior and anoestrus length in postpartum cows, *Bos indicus* heifers reach puberty older and at a higher percentage of body weight relative to mature body weight than *Bos taurus* heifers, resulting in a lower proportion of pubertal females at the beginning of the breeding season and lesser pregnancy rates (Filho and Vasconcelos, 2010).

Poor Semen Handling

One obvious factor which determines the degree of success of AI is the quality of the semen used. Much has been learned about factors affecting semen quality and methods of evaluation and means of maintaining quality through lengthy storage. The commercial AI industry has a tremendous responsibility to sell only high-quality semen (Webb, 2010). Careless semen handling is the second way artificial insemination (AI) can fail. The bull semen must be stored, transported and thawed correctly to ensure it remains viable (Chatikobo, 2009).

Failure to follow recommended procedures for retrieving, thawing, and protecting straws until safely inside the cow results in damaged sperm membranes, cold- and heat-shocked sperm, or impaired sperm motility. The final result is an overall reduction in the fertile life of the frozen-thawed sperm in the straw (Gil *et al*., 2005). The canister is an insulated container with vacuum insulation, for the preservation of semen, and for that he should receive liquid nitrogen, which preserves the doses of semen frozen at a temperature of (196 ºC) indefinitely, provided they maintain a certain level, supplying them periodically. It should be handled with the utmost care to avoid damage that may result in losses. To lessen the risks to the canister, it is advisable to build a wooden box for packaging, avoiding shocks, movements that are too fast, and overturning spilling its entire contents. The liquid nitrogen evaporates constantly, and the inseminator is alert to prevent loss of semen due to lack of nitrogen. To do so, you should always measure your level with the appropriate meter; never letting the level below 15 cm. High consumption of nitrogen can indicate problems with the canister as well as the formation of frost or condensate on any external surface may also indicate defects (Costa *et al*, 2004).

Several methods of obtaining semen have been developed. Namely, the use of artificial vagina, by Electro-stimulation method, by massaging the ampullae of the duct us differences through the rectal wall. Among these methods, the artificial vagina method is most widely used today for the collection of bull semen (Tnau, 2008).

Cleanliness must be practiced to avoid contamination and deterioration of semen quality. Proper and careful treatment of the bull is essential to bring about adequate pre-collection stimulation which will increase the quantity and quality of semen obtained. Obviously, the collection of semen from a bull is a specialized skill and should be attempted only by those with the proper equipment, training, and experience (Webb, 2010). Frozen semen is transported around the world and domestically most commonly in 'dry shippers. This is a shipping container that contains no free liquid nitrogen in the container whilst holding the semen at (–196°C). This enables frozen semen to be transported without being classed as dangerous goods (Nelson, 2010).

Freezing of semen for the successful preservation of spermatozoa, for long periods, is of great importance in livestock breeding and farm management. There are two methods of freezing and storing semen: dry ice and alcohol (-73.3 ^{0}C) and liquid nitrogen (-195.5 ^{0}C). Frozen semen will not deteriorate in quality over time, provided that the storage tanks are not allowed to 'go dry' (Tnau, 2008).

Poor Insemination Techniques

The technique of inseminating a cow is a skill requiring adequate knowledge, experience and patience. Improper AI techniques can negate all other efforts to obtain conception. Semen must be deposited within the tract of the cow at the best location and at the best time to obtain acceptable conception rates. Accurate placement of semen during artificial insemination is important for achieving good conception rates (Webb, 2010).

The faulty insemination technique is a major factor causing a low conception rate in many herds. Correct semen placement is critical (Nafarnda *et al*., 2005). An accurate insemination technique requires concentration, attention to detail, a clear understanding of reproductive anatomy, and the ability to identify the target area and properly position the insemination rod. The variation in this study and others suggests that certain individuals have acquired or perfected these skills to a much greater degree than others. It further demonstrates the need for routine retraining and updating of professional AI technicians and owner inseminators (Connor, 2003).

However, in order to benefit from the advantages of AI, farmers must detect the oestrus periods of their cows accurately, ensure that insemination is done at the correct time in relation to the onset of oestrus and detect any cows that later return to oestrus, so that they can be re-inseminated without delay. Even when these conditions are satisfied, optimum conception rates will only be achieved if the quality of semen used is good and the AI technicians have adequate training and skills in the procedures for handling semen and performing inseminations (Iaea, 2007).

Any attempt to improve the efficiency of AI has to be based on an understanding of the most important causes for failure under each specific production system. Lack of handling facilities makes AI difficult for the inseminators to follow proper semen handling procedures and times. The traditional methods used for this rely on accurate recording and analysis of reproductive events such as oestrus, services, pregnancies and calving. However, records are rarely kept by smallholders and, even when available, do not allow an assessment of the importance of factors such as efficiency and precision of oestrus detection by the farmers or incorrect timing of insemination (Chatikobo, 2009).

Difficult entry of the AI gun into the cervix could indicate that the animal is not in proper oestrus or has some pathological condition, such as infantile genitalia or an abnormal cervix. It may also be a reflection of the lack of expertise of the inseminator. This suggests that technical training in AI and knowledge of reproductive anatomy and physiology are important for the success of AI (Iaea, 2007).

Inability to Control Estrus Cycle

Although the oestrus cycle of the female is mainly governed by hormones that are secreted internally, there are other factors that exert a considerable influence on it, either directly or indirectly. The extent of their influence varies both between and within species and breeds. Apart from the abnormality of the disease, the most important factors affecting oestral cycle appear to be the plane of nutrition, the length of daylight, and ambient temperature. The inadequately fed female animal grows slowly and her sexual maturity, and hence the onset of her oestral cycle, is delayed. Very large numbers of tropical cattle have to subsist on low levels of nutrient intake for long periods during the year. As a consequence, the 1^{st} effective heat periods of heifers are often delayed until they are two years or older (Payne, 1990).

Environmental factors such as high temperatures decrease oestrus activity. Ooestrus behavior was greatest in dairy cows observed twice daily when ambient temperatures were less than 25 ^{0}C compared with temperatures above 30 ^{0}C (Todd, 2012). A combination of both visual observation and one or more of the detection aides increase the efficiency of oestrus detection compared with visual observation or detection aides alone (Looper, 2000).

Heat Synchronization is a slight modification of Ov Synchronization. The Ov Synchronization procedure involves the administration of GnRH seven days before injection of PGF_2". The injection of GnRH provokes either atresia or ovulation of antral follicles. PGF_2" then induces luteolysis of any luteal tissue, whether they are from spontaneous ovulation or the GnRH-induced ovulation seven days earlier. Ov Synchronization then utilizes a second injection of GnRH 48 hours later to provoke timed ovulation. Heat Synchronizations employs an injection of estradiol cypionate (ECP) 24 hours after the injection of PGF_2" rather than the second injection of GnRH. HeatSync then requires timed AI 48 hours later 72 hours after the injection of PGF_2" (Kesler and Steckler, 2002). The first results with Ov synchronization indicated that all non-pregnant cows could be enrolled into the protocol regardless of their stage during the oestrus cycle. To achieve success with these hormonal protocols, each farm has to develop a system to administer the correct injections to the correct cows on the correct days, then subsequently AI the correct cows (Grave, 2012).

A standard Pre-synchronization/Ovsynchronization protocol for submitting cows for the first AI service requires that each individual cow receive 5 consecutive injections at the appropriate injection intervals. Failure to administer any one of these 5 injections dramatically or completely reduces the conception risk to first timed AI and will ultimately result in a delay in establishing pregnancy (Fricke *et al*., 2012). Protocols using GnRH and PGF2 have afforded acceptable results in *Bos taurus* females (pregnancy rate 50%, but lower pregnancy rates have been reported for *Bos indicus* cows. However, a commercial source of estradiol is not available for oestrus cycle manipulation in many countries so other products (e.g., GnRH, LH) have been used to induce ovulation of dominant follicles and follicular wave synchronization (Filho *et al*., 2009a). The mechanism by which GnRH induces new wave emergence is based on inducing ovulation of dominant follicles, and its success is dependent on the presence of a dominant follicle with ovulatory capacity at the time of treatment, which is acquired when ovarian follicles are 8.5 mm in diameter in *Bos indicus* cattle (Filho and Vasconcelos, 2010b).

Artificial Insemination in Ethiopia

In Ethiopia, Artificial insemination (AI) was introduced in 1938 in Asmara, then the part of Ethiopia, which was interrupted due to the Second World War and restarted in 1952 E.C. It was again discontinued due to unaffordable expenses of importing semen, liquid nitrogen, and other related inputs requirement. In 1967 an independent service was started in the Arsi Region, Chilalo Awraja under the Swedish International Development Agency (SIDA). It has been described that the technology of Artificial insemination (AI) for cattle has been introduced at the farm level in the country over 35 years ago as a tool for genetic improvement (Zewdie *et al*., 2006).

When AI was first introduced into agriculture there was an enormous outcry from the farmers. It gradually has become an accepted practice in agriculture, as well as in human and veterinary medicine. The ability to freeze semen and a high degree of fertilizing ability after thawing extended the power of AI, since a few selected bulls could be used to inseminate many females in different geographical areas. By maintaining accurate records, breeding value estimations of particular bulls could be calculated and resulted in a remarkable increase in milk production noted earlier (Sasidhara, 2006). AI is commonly used in dairy and beef cattle to introduce superior genetics into the herd and to eliminate the need to keep a bull on the farm. While the artificial insemination technique seems simple, it takes experience and knowledge of a cow's reproductive system to successfully breed cows in this manner. The recto-vaginal technique is most commonly used as it has the greatest conception rate (Connor, 2003). First of all the equipment needed for insemination should be assembled. This includes the semen (usually frozen in thin tubes in a refrigerated tank), paper towels, an obstetrical sleeve, lubricating material, and the inseminating rod. The equipment must be kept clean to prevent the introduction of germs, dirt, or manure into the cow's reproductive tract (Nebel and Dejarnette, 2001).

The cow to be inseminated must be in estrus for the insemination to be successful. Cows in estrus will be restless, will mount other cows, and will allow other cows to mount her. The cow should be restrained in a place that is familiar to her to keep her calm. Usually, this will be in her normal stall, using a headlock, head gate or halter to keep her still. The semen is held in a pipette (straw) at an extremely low temperature. The selected straw is removed from the tank and thawed prior to placing it into the inseminating rod. Typically, the semen is thawed using a warm water bath at 32.2 to 35 ^{0}C for 40 to 60 seconds. This must be done before preparing the cow for insemination (Stevenson, 1997).

The obstetrical sleeve on the inseminator's non-dominant arm is placed and some lubricating materials are applied to the sleeve. The inseminator's arm is gently introduced into the rectum to clean manure from the rectum as he/she advances the arm into it. The cervix is located and stabilized and a paper towel is used to thoroughly wipe the vulva area and to clean dirty and manure. The towel is placed into the lower part of the vulva to spread the lips out, and the insemination rod is gently introduced at a 30 to 40-degree angle without touching the vulva (Nelson, 2010). Then the rod is passed through the vagina and cervical opening and into the uterus. Finally, the semen is slowly deposited into the uterus and the rod is removed after the semen has been delivered. Part of the semen is deposited just inside the uterus and the remainder in the cervix as the catheter is withdrawn. Expulsion of the semen should be accomplished slowly and deliberately to avoid excessive sperm losses in the catheter. The body of the uterus is short; therefore, care should be taken not to penetrate too deeply which might cause physical injury (Tanu, 2008).

Effects of The Artificial Insemination

Advantages of Artificial Insemination

AI is an essential technique in breeding programs with progeny testing. AI provides the opportunity to choose sires that have proven to transmit desirable traits to the next generation and minimizes the risk of spreading sexually transmitted diseases and genetic defects. So far, AI using frozen semen has played an important role in increasing genetic progress by upgrading the reproductive rate of males. It increases the selection intensity since less bull is needed and this is the basis for selection progress (Tadesse, 2010).

One of the major advantages of artificial insemination (AI) is the elimination of the costs and dangers of maintaining a bull on the farm. The use of AI has cumulative beneficial effects on dairy because of the opportunity of choosing sires that are proven to transmit superior genetic traits. The risk of spreading sexually transmitted diseases or genetic defects is also minimized when AI is practiced on a dairy farm. Natural mating allows for the transfer of venereal diseases between males and females. Some pathogens can be transmitted in semen through artificial insemination, but the collection process allows for the screening of disease agents. Collected semen is also routinely checked for quality, which can help avoid problems associated with male infertility (Chatikobo, 2009; Iaea, 2003).

The progeny testing can be done at an early age. The semen of the desired size can be used even after the death of that particular sire. The semen collected can be taken to the urban areas or rural areas for insemination. It makes possible the mating of animals with great differences in size without injury to either of the animals. It is helpful to inseminate the animals that are refusing to stands or accept the male at the time of oestrus. It helps in maintaining accurate breeding and caving records. It increases the rate of conception. It helps in better record keeping. Old, heavy, and injured sires can be used (Johnson, 2011).

Disadvantages of Artificial Insemination

Artificial insemination (like live breeding), requires that the cow is inseminated with sperm at the correct time to ensure the best chances of conception. AI is a trained skill, taking a lot of time and practice to carry out efficiently and effectively each time. Because of this, a qualified vet or animal technician will be needed and these can be costly (Thomas, 2011). Other disadvantages of Artificial insemination include poor conception rates due to poor heat detection and inefficiency of AI technicians, dissemination of reproductive diseases and poor fertility rates, and if AI centers are not equipped with appropriate inputs and are not well managed (Gebre Medhin, 2005). High cost of production (collection and processing), storage and transport of semen, as well as budget and administrative problems, and inefficiency of AI technician is also other disadvantages of AI (Desalegn, 2008).

When receiving semen from another state or country, the timing becomes even more imperative, as it needs to arrive within the correct time frame to thaw out and place in the cow. AI can be quite labor-intensive when it comes to lining up the cow to inseminate and so becomes costly due to regular vet checks. AI decreases the value of stock and increases the chances of cattle being largely inbred (Shehu *et al*., 2010). Artificial insemination can be limited if the proper resources are not available, so there are some disadvantages. AI requires specialized knowledge, and trained individuals and the time required to properly execute an effective AI program is considerably more than with natural service. The extra help and time can often mean added expense (Gentry, 2010).

Economic Impacts of Artificial Insemination

In dairy farming like every other business, profit is the difference between expenses and revenue. The simplicity of this statement hides two problems. First, expenses occur before revenue is realized. Second, it is almost always easier to estimate expenses than it is to predict revenue. Unfortunately, it is necessary to spend money to make money. It is not a goal to maximize expenses, but neither is it a goal to minimize expenses. Reproduction on a dairy farm is a dramatic example of this concept. Reproductive expenses occur months to years before the revenue is realized. The economic gains from reproductive management are greatest during periods of high milk prices and are greater for herds with high levels of milk production (Fricke *et al*., 2012).

Reproductive efficiency of the dairy herd is important to the economic success of the dairy operation. Thus, the efficient and accurate detection of estrus and the proper time of insemination is of utmost importance if dairy producers want to increase the reproductive efficiency of the herd (Looper, 2000). Herd health programs, as recommended by the veterinarian, must include a way to avoid metabolic disorders and prevent or control infectious diseases. Frequently when metabolic disease increases, the opportunistic infectious disease also increases. Stress from metabolic problems may decrease the cow's resistance and compromise immune system function. If these diseases are not prevented, very costly consequences in the reproductive, milk production and human resource areas will occur (Smith *et al*., 2007).

Bovine reproductive diseases and conditions result in economic losses caused by decreased production and delayed reproduction as well as increased treatment and preventative measurement costs (Suzanne, 2009). Economic considerations illustrate the impact AI can have and perhaps in today's marketing environment the argument for AI has grown stronger. One major consideration is that to utilize AI effectively and reap some of the economic benefits it must be coupled with an effective oestrus synchronization protocol (Miller, 2011).

Conclusion and Recommendations

Artificial insemination (AI) is the manual placement of semen in the reproductive tract of the female animal by a method other than natural mating. AI is one of the technologies usually referred to as assisted reproduction technologies (ART), in which, offspring are produced by enabling the meeting of gametes (spermatozoa and oocytes). And uses three main techniques they are Intravaginal, Intracervical, and Intrauterine and where spermatozoa or embryos, or occasionally oocytes are cryo-preserved in liquid nitrogen for use at a later stage. It has various applications such as improving the genetics of farm animals; it has been most widely used for breeding dairy cattle and has made bulls of high genetic merit available to all animals and research model. And it has major problems associated with artificial insemination services, like, as the inability to detect oestrus, disease, management problem, poor inseminating technique, poor semen handling, and inability to control the estrus cycle. Thus, based on the above conclusive statements, the following points are forwarded:

- Further technological experiments should be done to improve the techniques of AI.
- There awareness should be created to clinicians about the major problems associated with artificial insemination services.
- Educating the livestock owners about the importance of AI and timely heat detection and appropriate time of insemination

List of Abbreviations

AI-Artificial Insemination, AITs-Artificial Insemination Trainings, ART-Assisted Reproduction Technologies, ET-Embryo Transfer, GIFT-Gamete Intra-Fallopian Transfer, GnRH-Gonadotropin Releasing Hormone, ICI-Intra-Cervical insemination, ICSI-Intra-Cytoplasmic Sperm Injection, IPVV-Infectious Pustular Vulvo-Vaginitis, IUI-Intrauterine Insemination, IVF-In-Vitro Fertilization, LH-Luteinizing Hormone, LN-Liquid Nitrogen, NAIC-National Artificial Insemination Center, NEB-Negative Energy Balance, PGF2-Prostaglandin F2α, SIDA-Swedish International Development Agency

Conflict of Interests

There is no conflict of interest.

Publisher Disclaimer

IJLR remains neutral concerning jurisdictional claims in published institutional affiliation.

References

1. Agaze, T., Berhanu, G. and Dirk, H. (2010). Livestock Input Supply and Service Provision in Ethiopia: Challenges and Opportunities for Market-Orented Development. *IPMS, ILRI, Addis Ababa, Ethiopia*. pp.10-12.
2. Alemayehu, L. (2010). Artificial Insemination and Veterinary Services in Ethiopia: Factors affecting the effective delivery of Artificial Insemination in Ethiopia: Ada'a case presentation by Alemayehu Lemma to the Ethiopian Fodder Roundtable on Effective Delivery of Input Services to Livestock Development.
3. Anel, L., Kaabi, M., Abroug, B., Alvarez, M., Anel, E., Boixo, J., de la Fuente, L. and de Paz, P. (2005). Factors influencing the success of vaginal and laparoscopic artificial insemination in churra ewes: a field assay. *Theriogenology,* **63**(4): pp1235- 1247.
4. Ayad, V.J., Leung, S.T., Parkinson, T.J. and Wathes, D.C. (2004). Coincident increases in oxytocin receptor expression and EMG responsiveness to oxytocin in the ovine cervix at oestrus. *Anim. Reprod. Sci*.**80** (3-4):237-258.
5. Bellows, D., Ott, S. and Bellows, R. (1993). Review: Cost of Reproductive Diseases and Conditions in Cattle. *Journal of Animal science*.**18**, pp. 27-31.
6. Bols P, Langbeen A, Verberckmoes S, Leroy J (2010). Artificial insemination in livestock production: *The Vet's perspective. F, V & V In Obgyn. Monograph*: (3) pp 6-12.
7. Bols, P., Langbeen, A., Verberckmoes, S. and Leroy, J. (2010). Artificial insemination in livestock production: *the Vet's perspective. F, V & V InObgyn. Monograph*: pp 6-
8. 12.
9. Caraviello, D., Weigel. K., Fricke P. and Wiltbank, M. (2006). Survey of Management
10. Practices on Reproductive Performance of Dairy Cattle on Large US Commercial Farms. University of Wisconsin, *Madison , Inc*. **89**, pp. 4723.
11. Chebel, R.C. (2010). Mastitis and BCS Loss Affects Fertility. Reproductive performance is quickly becoming the biggest challenge in dairy herds' profitability, according to Ricardo C. *Chebel, DVM, Department of Veterinary Medicine, University of Minnesota*.
12. CSA, (2006). (Central Statistics Agency), Federal Democratic Republic of Ethiopia: Agricultural Sample

Survey 2006/07, volume II, Report on livestock and livestock characteristics. *Statistical Bulletin 388. Addis Ababa, Ethiopia*. **9** (10):25- 27.

13. CSA. (2017). Federal Democratic Republic of Ethiopia Central Statistical Agency, Agricultural Sample Survey 2016/17 (2009 E.C.). Volume II Report On Livestock and Livestock Characteristics. Statistical bulletin 585, Addis Ababa, Ethiopia.
14. Desalegn, G. (2008). Assessment of problems/constraints associated with Artificial Insemination service in Ethiopia. Addis Ababa University, Faculty of Veterinary Medicine, Debrezeit, Ethiopia, **2**(4):67-69.
15. Dobson, H., Walker S. L., Morris M. J., Routly J. E. and Smith, R. F. (2010). Why is it getting more difficult to successfully artificially inseminate dairy cows? Department of Veterinary Clinical Science, University of Liverpool, Leahurst, Neston, Wirral CH64 7TE, UK.
16. Donovan, A., Hanrahan, J., Kummen, E., Duffy, P., and Boland, M. (2004).Fertility in the ewe following cervical insemination with fresh or frozen-thawed semen at a natural or synchronisedoestrus.Anim. *Reprod. Sci*., **84**(3-4):359-368.
17. Filho, O.G. and Vasconcelos, J.M. (2010). Treatments to optimize the Use of Artificial Insemination and Reproductive Efficiency in Beef Cattle under Tropical Environments. UNESP, SP, Brazil.
18. Foote, R. H. (2002). The history of artificial insemination: Selected notes and notables. *American Society of Animal Science*, **12**(4) pp126-127.
19. Francisco, Carranza, Esther Santamaría, Cristina, González-Ravina, VíctorBlasco, CinziaCaligara and Manuel (2015). How to Perform the Best Intrauterine Insemination? *A Review* **4**(2):1-8.
20. Gebremedhin, D. (2005). All in one: A practical Guide To Dairy Farming. Agri-service Ethiopia Printing Unit. Addis Ababa. pp. 17.
21. Gil, M., Roca. J., Cremades. T., Hernandez.M. and Vazquez, H.(2005): Does multivariate analysis of post-thaw sperm characteristics accurately estimate in vitro fertility of boar individual ejaculates? *Theriogenology* **64**:305-316.
22. Jodie, A.P. (2006). Dairy Reproductive Management Using Artificial Insemination.University of Arkansas Division of Agriculture, Coopirative Extension-service, Little Rock.
23. Kaabi, M., Alvarez, M., Anel, E., Chamorro, C.A., Boixo, J.C., de Paz, P., and Anel, L. (2006). Influence of breed and age on morphometry and depth of inseminating catheter penetration in the ewe cervix: a postmortem study. *Theriogenology*, **66**(8):1876-1883.
24. Khalifa, T., Lymberopoulos, A.G. and El-Saidy, B.E. (2008). hydroxytoluene in conservation). Testing usability of butylated of goat semen. *Reprod. Domest.*
25. *Anim.*, **43**(5):525- 530.
26. King, M., McKelvey, W., Dingwall, W., Matthews, K., Gebbie, F., Mylne, M., Stewart, E.
27. and Robinson, J. (2004). Lambing rates and litter sizes following intrauterine or cervical insemination of frozen/thawed semen with or without oxytocin administration. *Theriogenology*,**62**(7):1236-1244.
28. Kubkomawa, H. (2017). The Use of Artificial Insemination (AI) Technology in Improving Milk, Beef and Reproductive Efficiency in Tropical Africa: A Review; *Journal of Dairy & Veterinary Sciences*; **5**(2):001-18
29. Kubkomawa, H. (2018) The Use of Artificial Insemination (AI) Technology in Improving Milk, Beef and Reproductive Efficiency in Tropical Africa: *A Review Dairy & Veterinary Sciences*, **5**(2):001-0018.
30. Lobago, F. (2007). Reproductive and Lactation Performance of Dairy Cattle in the Oromia Central Highlands of Ethiopia with Special Emphasis on Pregnancy Period. Doctoral thesis, Swedish University of Agricultural Sciences, Uppsala.
31. Merga, B., Abayneh, T. and Gizaw, Y. (2010). Major reproductive health problems in Smallholder dairy production in and around Nazareth town, Central Ethiopia.
32. Million T., Tadele D., Gifawesen T., Tamirate D. and Yohannis G. (2006). A study on age at first calving, calving interval and breeding ifficiency of bostaurus and bosindicus and their crosses in the highlands of Ethiopia. Ethiopian journal of animal production.*Debzeit agricultural research center, ILRS, Holeta agricultural research center, Ethiopia*: **6**(2):3.
33. Nafarnda.W., Kubkomawa. I., Mshellia. A., Nesati. Y. (2005). Evaluation of Fertility Rate in Friesian and White Fulani (Bunaji) Breeds of Cattle Following Artificial Insemination.*Global Journal of Agricultural Science* **14**(2):155-157.
34. Nebel R. and Dejarnette T. (2001).Artificial Insemination Technique in Cattle. Available at:www.selecsires.com/resource/fertility docs/ai-techniqu-cattle.pdf.
35. Ombelet, W., Dhont, N., Thijssen, A., Bosmans, E. and Kruger, T. (2014). Semen quality and prediction of IUI success in male subfertility: a systematic review. Reprod Biomed Online **28**:300-309.
36. Ombelet, W., Martens, G., De., Sutter P, Gerris, J., Bosmans, E., Ruyssinck, G., Defoort,

37. P., Molenberghs, G. and Gyselaers, W. (2006). Perinatal outcome of 12,021 singleton and 3108 twin births after non-IVF-assisted reproduction: a cohort study. Hum Reprod **21**:1025–1032.
38. Ombelet.W., Rud.i C., Eugene. B, and Martine. N (2008). Intrauterine insemination (IUI) as a first-line treatment in developing countries and methodological aspects that might influence IUI success, *Human Reproduction and Embryology*: pp64-72.
39. Paulenz, H., Soderquist, L., Adnoy, T., Nordstoga, A.B., and Andersen, Berg, K. (2005). Effect of vaginal and cervical deposition of semen on the fertility of sheep inseminated with frozen-thawed semen.
40. Sakhel K, Schwarck S, Ashraf M, Abuzeid M (2005) Semen parameters as determinants of success in 1662 cycles of intrauterine insemination after controlled ovarian hyperstimulation. *FertilSteril* **84**: 248-249.
41. Sasidhara, R. (2006). Animal Biotechnology. Chennai, MJP, India. pp. 16-17.
42. Sasidhara, R. (2006). Animal Biotechnology. Chennai, MJP, India. pp. 16-17. Connor M. (2003). Reviewing: Artificial Insemination Technique.The Pennsylvania State University. ICT3420. Available at:
43. Shehu, B.M., Rekwot, P.I., Kezi, D.M., Bidoli, T.D. and Oyedokun, A.O. (2010). Challenges to Farmers' Participation In Artificial Insemination (AI) Biotechnology In Nigeria: An Overview. *Ahmadu Bello UniversityZaria*.**14** (2):123-124,
44. Stevenson, J.S. (1997). Techniques to Maximize Conception Rates.Dept.of Animal Sciences, Kansas State University, Manhattan, KS, 66506-0201, U.S.A. Nelson M. (2010).Cattle Artificial Insemination Techniques. Available at: http://www.ehow.com/list_6760227_cattle-artificial-insemination-techniques.html.
45. Accessed on April 22, 2012.
46. Suranaree (2009). Development Of Trans-Cervical Artificial Insemination In Sheep With Special Reference To Anatomy Of Cervix Sci. Technol. **17**(1):57-69.
47. Suzanne Ch. (2009). Reproductive Disease of Dairy cattle.Dairy Science Department.College of Agriculture and Environmental Science.California Polytechnic State University. San Luis Obispo. pp. 6, 26.
48. Tadesse, A. (2010). The Status and Constraints of Artificial Insemination In Cattle In The Three Selected Districts Of Western Gojjam Zone of AmharaRegion, Ethiopia. Department of Animal Production And Technology, College Of griculture And Environmental Sciences, School Of Graduate Studies Bahir Dar University.*Journal of Agriculture & Social Science*, pp.103.
49. Thrusfield, M. (2005). Veterinary epidemiology. 3rd edn. Blackwell Science, pp. 182-184.
50. Troedsson.M., Loset. K., Alghamdi. A., Dahms. B., Crabo. B. (2001). Interaction between equine semen and the endometrium: the inflammatory response to semen. *Anim Reprod Sci* **68**:273-278.
51. Webb, D.W. (2003): Artificial Insemination in Cattle. University of Florida, Gainesville.
52. *IFAS*, *Extension*, DS **58**:1-4.
53. Woldu, T., Giorgis, Y. T. and Haile A. (2011). Factors affecting conception rate in artificially inseminated cattle under farmers condition in Ethiopia. 1Jimma University College of Agriculture and veterinary Medicine, Jimma, Ethiopia.2Hawassa University, Hawassa, Ethiopia. 3International Livestock
54. Research Institute (ILRI), Addis Ababa, Ethiopia. Journal of Cell and Animal Biology, **5**(16):335-342.
55. Zewdie, E., Mussa A., Melese G.M., HaileMariam D. and Perera, B. (2006). Improving artificial insemination services for dairy cattle in Ethiopia.Improving the reproductive management of smallholder dairy cattle and the effectiveness of artificial insemination services in Africa using an integrated approach. *International Atomic Energy Agency*, pp. 17-19.
56. Tnau, (2008). Artificial Insemination. Available at:http://agritech.tnau.ac.in/animal husbandry/animhus cattle AI.html. Accessed on April 14, 2012.
57. Nelson, M. (2010). Cattle Artificial Insemination Techniques. Available at:
58. http://www.ehow.com/list_6760227_cattle-artificial-insemination-techniques.html.
59. Accessed on April **22**, 2012.
60. Kruif A. (2005). Factors influencing the fertility of a cattle population. Clinic of Veterinary Obstetrics, Gynaecology and A.L, State University of Utrecht, "De Uithof", Utrecht, Netherlands. **54**:509-510, 511.
61. Looper, M. (2000). When Should Dairy Cows Be Inseminated? College of Agricultural, Consumer and Environmental Sciences New Mexico State University.
62. Kesler.D. and Steckler. T. (2002). Synchronization of Estrus with Heatsync. University of Illinois.
63. Kononoff P., Smith D. and Keown J. (2007).Dairy cow health and metabolic disease relative to nutritional factor. Available at: docs/ai-techniqu-cattle.pdf. www.selecsires.com/resource/fertility.
64. Gustafsson H. and EmanuelsonU. (2002). Characterisation of the Repeat Breeding Syndrome in Swedish Dairy Cattle.Swedish University of Agricultural Sciences, Uppsala, Sweden.Acta Veterinaria Scandinavica. **43**(2):117-121.
65. Chatikobo, P. (2009). Artificial Insemination in Rwanda: Exploring Opportunities, Overcoming Challenges.

EADD, Rwanda.

66. Santos, P. (2008).Impact of Nutrition on Dairy Cattle Reproduction. Nutrition has an important impact on the reproductive performance of dairy cattle, writes.,Ph.D.Department of Animal Sciences, University of Florida. This feature was taken from the proceedings of the High Plains Dairy Conference.
67. Costa L., Nelson A., Araujo A. and Feitosa J. (2004). Particularities of Bovine Artificial Insemination.Federal University of Ceara, Brazil.
68. IAEA (International Atomic Energy Agency), (2003).Artificial insemination (AI) of cattle.WagramerStrasse, Vienna, Austria. Available at: http://wwwnaweb.iaea.org/nafa/aph/resources/technology-ai.html. Accessed on April 18, 2012.
69. IAEA (International Atomic Energy Agency), (2007). Improving the Reproductive Management of Dairy Cattle Subjected to Artificial Insemination. Veinna. Available, at: http://agritech.tnau.ac.in/animal_husbandry/animhus_cattle_AI.html.
70. Accessed on January 14, 2021.
71. Todd, R. (2012).Strategies to Improve Reproduction during summer. Available at:
72. http://www.extension.org/pages/62993/strategies-to-improve-reproduction-duringsummer. Accessed on January,13, 2021.
73. Payne, W. J. A., (1990). An Introduction to Animal Husbandry in the Tropics.4th Edition, *John Wiley and Sons, Inc, NewYork.* Pp. 143-144, 172-173.
74. Graves, W. M. (2009).Heat Detection Strategies for Dairy Cattle.Assebility statement. The University of Georgia and Ft. Valley State University, the U.S.
75. Fricke, P., Burstein D. and Guenther J. (2007). Artificial Insemination Techniques for Dairy Cattle Spanish and English.University of Wiskon.
76. Filho, O.G., Vilela, E.R., Geary, T.W. and Vasconcelos, J.M. (2009).Timed Artificial Insemination with GnRH and $PGF_{2\alpha}$. Strategies to improve Fertility in Post partumMultiparousBosIndicus Cows Submitted to a Fixed-Time Insemination
77. Protocol with GnRH and $PGF_{2\alpha}$.
78. Smith, D. R., Kononoff, P. and J. and Keown J. F., (2007). Dairy Cow Health and Metabolic Disease Relative to Nutritional Factors.ThisNebGuidedescribes the various implications and effects of dairy cow metabolic problems, their causes, and management recommendations for prevention.
79. Ubkomawa, H. (2018): The Use of Artificial Insemination (AI) Technology in Improving Milk, Beef and Reproductive Efficiency in Tropical Africa: *A Review Dairy and*
80. *Vet Sci J*., **5**(2):
81. Costa, L., Nelson, A., Araujo, A. and Feitosa, J.V. (2004). Particularities of Bovine Artificial Insemination. Federal University of Ceara, Brazil.
82. Murray, B. (2010). Dairy Cattle Reproduction**.**Heat Detection and Timing of Insemination. Ministry of Agriculture, Food and Rural Affairs: *Dairy Cow Heat Detection*.
83. Graves, W. (2009). Heat Detection Strategies for Dairy Cattle.Assebility statement.The University of Georgia and Ft. *Valley State University, the U.S*.
84. Lopez, H., Satter, L.D. and Wiltbank, M.C. (2004). Relationship between level of milk production and oestrusbehaviour of lactating dairy cows.*Animal Reproduction Sci*., **81**:214.

****