International Journal of Research Studies in Microbiology and Biotechnology
Volume 4, Issue 1, 2018, PP 30-43
ISSN No. (Online) 2454-9428
DOI: http://dx.doi.org/10.20431/2454-9428.0401005
www.arcjournals.org

Artificial Insemination and its Economical Significancy in Dairy Cattle: Review

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Abstract: *Artificial insemination (AI) is the act of collecting semen from the male, preserving it until use, and depositing it in the reproductive tract of the female when she expresses estrus. The semen may be sexed if desired. AI has its advantages and disadvantages. It allows for better utilization of sires, reduces the hazards and costs of keeping males, and allows for the utilization of multiple sires. However, it requires extensive training and skill development, has a high initial investment, has maintenance costs, and increases requirements for management. Animal producers should weigh the positives and the negatives to determine if AI is appropriate for their production systems. Artificial insemination is placing collected fresh, stored or cryopreserved semen intravaginaly, transcervical or intrauterine artificially. A pioneer biotechnology of reproduction, which was 1st started in Italy by Abbe Lazzaro Spallanzani (1870) and have been used in Ethiopia and other countries. Evaluation of female gynecological and technique of estrus detection and investigation of male fertility are mandatory for successful AI. Although AI is the powerful tool for the detection and management of genetic merits it have disadvantages and constraints if we don't follow the correct procedure. So we have to detect estrus correctly, inseminate timely and we have to follow correct procedures of semen preparation for satisfactory results. And also their should be one national body that is responsible to coordinate and monitor AI service, herd recording, livestock breeding programs and be very well organized in human and material resources to get the expected results.*

Keywords: *Artificial insemination, estrus detection*

1. Introduction

Ethiopia is resourceful country endowed with estimated larges livestock population in Africa. The livestock sector has a significant role in socioeconomic activity of the country and contributes much to the national economy (CSA, 2016) which is about 17 % of the national gross domestic product (GDP) and 36 % of agricultural GDP (Metaferia et al. 2011). The contribution of livestock to the national economy particularly with regard to foreign currency earnings is through exportation of live animal, meat and skin and hides (Ayele et al., 2003, FAO, 2005). However, development of this sector is hampered by different constraints. The most important constraints are widespread endemic diseases, includes lack of appropriate disease control policy, lack of appropriate veterinary services, lack improved livestock genetics, lack of attention from government (Zewdie, 2004; Birhanu, 2014).

Even if Ethiopia has a large cattle population the reproductive performance and the productivity of the indigenous cattle breed is low. Usually, cows do not produce their first calves earlier than 35-53 months of age and calving interval is about two years. Cross breeding is an acceptable procedure for profitable livestock production. It widely used in the world in order to enhance production of milk, meat, particularly at Commercial farms. Significant hetrosis values are usually obtained under optimum conditions by combining indigenous and exotic (Abejehu et al., 2002).

Cattle production in the country is source of food and cash income. Cattle production system in Ethiopia is mainly small holder substance farming, with animals having multipurpose use and as such no specialized and systematic breeding is used (Giday, 2001).

The livestock sector is one of the fastest growing segments of the agricultural economy particularly in the developing world (Delgado *et al.,* 2009). Although, Artificial Insemination (AI) has been considered as a promising tool to improve genetic potential of dairy animals, yet, many farmers at field conditions are unaware about the technology with huge regional variations in terms of knowledge level and adoption of this promising technology (Foote, *2002*).

AI plays an important role to increase the yielding capacity of cows and is the appropriate and cheapest way of genetic improvement and the realization of breeding programs has to be well organized and excited in a very reliable way and AI is fully functional when it is corporated with good animal husbandry such as effective heat detection (Noakes, 2009).

AI has proven to be a very effective reproductive technology that selectively increases genetic gain through increased selection pressure on males. Farm animals, males as well as females, are usually chosen for breeding programs based on breeding soundness examinations (BSEs). These BSEs determine suitability and likelihood of females or males to participate successfully in breeding programs. Estrus cycles of females can be manipulated to institute efficient insemination programs. With the use of these estrus synchronization programs, large groups of females can be inseminated at the same time. This does not only have the advantage of concentrating work on specific days during breeding (Webb, 2003).

Another reason for AI is to ensure effective use of semen. An increased number of offspring from a superior sire can be produced when AI is employed. Freezing bull semen can provide up to 200 straws of frozen semen from one ejaculate, equaling 200 AI doses. Overuse of males is prevented and commercial distribution facilitated. Other important aspects are the prevention of venereal disease transmission, for example, Trichomonosis and Campylobacteriosis both of which decrease reproductive efficiency through decreased pregnancy rates, high return rates to estrus and increased pregnancy losses, that plays a major role in the economic system of offspring production, and increased safety for valuable breeding animals as mating related injuries are avoided. Furthermore, AI can be used for frozen semen from males that have died or are not physically available for mating due to distance or physical inability (Gamborg, 2005).

In livestock rearing, the producer makes efficient use of the generous supply of sperm available from an individual male in a manner that greatly increases genetic progress, as well as improving reproductive efficiency in many situations. Today, many bulls have been reported to produce sufficient semen to provide enough sperm for 40,000 breeding units in one year (Bearden *et al.*, 2004).

The objective of this paper is to review the available literature on the economic value of AI in dairy farm.

2. LITRATURE REVIEW

2.1 Definition and History of Artificial Insemination

Artificial insemination (AI) or introduction of semen in the female genital tract by means of instruments is the first generation of reproductive biotechnologies which was feasible in cattle. It is a process by which sperm are collected from the male, processed, stored and artificially introduced into the female reproductive tract for the purpose of conception (Webb, 2003; Temesgen *et al.,* 2017). The first commercial AI cooperative was established in 1936 by a Dane, Sorenson (Foote, 2002). Before the Second World War, most cows in Europe and North America were fertilized by means of natural service. However, since several cows on different farms were mated by the same bull, the spread of genital diseases with decreased fertility outcomes was a constant threat. Moreover, keeping herd bulls was expensive and represented potential danger for the herd manager (Vishwanath, 2003).

Apart from these facts, the limited number of offspring produced per bull after natural mating made it impossible to set up effective progeny testing schemes and resulted in a very poor genetic gain. The introduction of AI in cattle was mainly forced by sanitary reasons, and especially by fertility problems caused by *Campylobacter foetus* subspecies *venerealis* (vibriosis) and *Trichomonas foetus*. However, also the control and prevention of non-sexually transmitted diseases such as tuberculosis, brucellosis and paratuberculosis at the farms benefited from the introduction of AI (Thibier and Guerin, 2000).

Semen is collected from the bull, deep-frozen and stored in a container with Liquid Nitrogen at a temperature of minus 196 degrees Centigrade and made for use. Artificial insemination has become one of the most important techniques ever devised for the genetic improvement of farm animals. It has been widely used for breeding dairy cattle as the most valuable management practice available to the cattle producer and has made bulls of high genetic merit available to all (Webb, 2003; Bearden *et al.*, 2004; Temesgen *et al.,* 2017). In livestock rearing, the producer makes efficient use of the generous supply of sperm available from an individual male in a manner that greatly increases genetic progress, as well as improving reproductive efficiency in many situations. Today, many bulls have been reported to produce sufficient semen to provide enough sperm for 40,000 breeding units in one year (Bearden *et al.,* 2004).

The first successful insemination was performed by the Italian physiologist and priest Abbe Lazzaro Spallanzani (1780) in a dog which whelped three pups 62 days later (Foote, 2002). And over 100 years later, in 1890, it was used for horse breeding. According to (Webb, 2003), the history of AI is interesting in that old Arabian documents dated around 1322 A.D. indicate that an Arab chieftain wanted to mate his prize mare to an outstanding stallion owned by an enemy. He introduced a wand of cotton into the mare's reproductive tract, and then used it to sexually excite the stallion causing him to ejaculate. The semen was introduced into the mare resulting in conception. In 1899, Ivanoff of Russia pioneered AI research in birds, horses, cattle and sheep, and was apparently the first to successfully inseminate cattle artificially. Mass breeding of cows via AI was first accomplished in Russia where 19,800 cows were bred in 1931 (Webb, 2003; Temesgen *et al.,* 2017)

2.2. Artificial Insemination Techniques

In Britain, AI in dairy cattle began to be available in 1942, and by 1950 20% of dairy cattle were being inseminated. By 1960, more than 2 million cows were inseminated yearly, which was about 80% of the maximum level that AI would reach (Brassley, 2007). The established procedure for AI in cattle since the 1960s is transcervical deposition of semen into the uterine body. This technique replaced the original vaginal or shallow cervical insemination performed in the 1940s as the intrauterine method proved to be more efficient and resulted in higher fertility (Lopez-Gatius, 2000).

2.2.2. Evaluation of female gynaecological

All females of reproductive age in a herd must be submitted to gynecological examination for selection of suitable animals for artificial insemination program. This is an internal examination by rectal palpation, ultrasound and vaginoscopy and can be complemented by laparoscopy and biopsy. On rectal palpation and ultrasonography are checked the size, consistency and contraction of the uterus, uterine horns and symmetry. In the ovaries are observed consistent form and size of follicles, cysts and persistent corpusluteum. Vaginoscopy complements rectal palpation and ultrasonography, because it turns out the shape of the vaginal portion of cervix, the opening degree of the cervical canal, mucosa color, moisture content and characteristic vaginal and cervical mucus. Gynecological examination involves a complete evaluation of all components of the external and internal genitalia, with emphasis on the ovaries, combining the findings of the examination with a score of animal body, with its history and with the herd (Antonio *et al*., 2011)

2.2.2. Bull health control

Disease prevention in bulls has been considered as essential as in breeding females and new bulls need to be screened by a qualified veterinarian for infectious agents prior to entering a new herd. Bulls have been recommended to be purchased only from reputable seed stock producers with adequate herd health plans; including vaccination against infectious diseases, e.g. leptospirosis and campylobacteriosis. Bulls are also recommended to be tested annually for brucellosis, but not be vaccinated for brucellosis. In some instances, bulls need to be vaccinated for bovine viral diarrhea (BVD), infectious bovine rhinotracheitis (IBR), and trichomoniasis (Hansen, 2006).

The frequency of tests made and the diseases tested at NAIC are not sufficient (Agegnehu, 2007). According to the international animal health code of the Office International des Epizooties (OIE)), donor and teaser animals should be tested for the following specific diseases: Bovine Brucellosis, Bovine Tuberculosis, Bovine Viral Diarrhea, Infectious Bovine Rhinotracheitis, *Campylobacter fetus/subspecies veneralis, Trichomonas fetus* (OIE, 2001).

2.2.3. Investigation of bull fertility

Infertility or sterility has been accepted as common problem in the male as in the female but because of the greater hazards presented by parturition and pregnancy, acquired infertility or sterility, however, is much more frequent in the female. Bulls selected for AI have been shown to transmit to their offspring the genetic potential for well-above-average milk or meat production (Herman *et al.,* 1994). In addition, the progeny must be of desirable conformation, be long wearing, have quiet disposition, and be free of genetic defects (Herman *et al*., 1994).

Evaluating sexual desire (libido) which can be affected by age, heredity, environment and poor feeding retards its onset (Hansen, 2006). Full libido may be achieved before normal spermatogenesis and therefore, as a rule animals are not put to stud until a few months after puberty. Bulls retain normal sexual desire until five or six years of age, but beyond this point libido very gradually wanes. Inability to perform service despite normal sexual desire is a frequent cause of bull infertility, has been reported to be due to skeletal or visceral pain, in others to lesions of the genital organs, inability to protrude and penile deviations, while in many cases in which no lesions can be found the nervous control of copulation is believed to be defective (Arthur *et al.,* 1983).

2.2.4. Other considerations

Scrotal circumference provides a good indication of a bull's ability to produce sperm and is related to his own age at puberty. The measurement should be taken at the largest diameter of the scrotum. Both testicles should be positioned next to each other and a flexible measuring tape should be placed snugly around the scrotum. Testicles need to be descended into the scrotum, and should be of the same size and shape. Any irregular shape or swelling may indicate abnormal structure, illness, or injury (Hansen, 2006).

Table 1. *Recommended scrotal circumference for Bos indicus bulls*

Age	Very Good	Good	Poor
12 months	>22 cm	18-22 cm	<18 cm
13 months	>24 cm	20-24 cm	<20 cm
14 months	>26 cm	24-26 cm	<24 cm
15 months	>30 cm	26-30 cm	<26 cm
16-20 months	>31 cm	28-31 cm	<28 cm
21-24 months	>32 cm	29-32 cm	<29 cm
25-31 months	>35 cm	31-35 cm	<31 cm
Over 31 months	>39 cm	34-39 cm	<34 cm

Source: (Hansen, *2006).*

2.3. Methods of Semen Collection

2.3.1. Artificial vaginas

A 45 cm long outer rubber-barrel with rough inner rubber liner that is not spermiotoxic is recommended. The inner liner should periodically be checked for possible leakages. The rubber cones should be also is non-spermiotoxic and a correctly labeled collection tube should be attached. A jacket for the cone should be provided to prevent breakage and avoid direct exposure to sunlight. Rubber bands for holding on the cones and two ends of the reflected inner lining onto the outer barrel should be strong. Sterile and non-spermotoxic lubricant (e.g. KY jelly, which has been tested and found to be non-toxic in diluted form) should be applied sparingly and just before collection (Fig.1). The lubricant can be replaced by a small amount of diluents to moisten the entrance to the artificial vagina (IAEA, 2005).

Figure 1. *Collection of semen with the artificial vagina. The left hand touches only the preputial skin, not the penis itself.*
Source: (IAEA, 2005).

2.3.2. Electroejaculators

The semen collected by electro ejaculation is equal in quality to that collected by the artificial vagina, and processing, storage, and later use are comparable. The method of electro ejaculation for semen collection is preferred to the artificial vagina method under certain conditions. It has been used for dairy bulls that have become crippled, have low sexual activity due to age, or for other reasons are unable to serve the artificial vagina. However, semen should not be collected and used from males that have not demonstrated normal sexual behavior or ability to ejaculate, as the cause may be genetic and transmitted to the offspring (Bearden *et al.*, 2004).

Electroejaculators should only be used when absolutely necessary. Injured or sick bulls should not be subjected to the technique. Good training and good handling procedures allow most bulls to be collected with the artificial vagina. Some *Bos indicus* bulls with low libido may not always respond to standard procedures and will require electroejaculation. The prepuce should be washed and dried. The rectum should be emptied of faeces and the probe inserted to lie over the seminal vesicles and ampullae. Stimuli should be applied with great care to achieve a very slow and gradual increase in intensity (IAEA, 2005).

2.4. Semen Evaluation

2.4.1. Volume

The volume of the ejaculate is readily measured by collecting the sample directly into a graduated vial .Alternatively, it can be done by weighing the tubes after semen collection on top-loading balance, and later converting the reading into milliliter by using a computer program (Bearden and Fuquary, 2000).The volume has been reported to decline when young bulls are used or when there is frequent ejaculation or incomplete or failure of ejaculation and in bilateral seminal vesiculities. Other factors like season of the year, method of collection, and the sexual preparation of the bull have been known to affect semen volume. The volume of bull's semen varies between ejaculates, individual bulls, breed, and age. However, a bull with less than 2ml of semen per ejaculate is not acceptable (Zewdie *et al.*, 2005). Semen volume for *Bos taurus bulls* in Brazil was reported to be 6.9ml and 8.2ml in different years (Brito *et al.*, 2002).

2.4.2. Mass activity

The mass activity is evaluated by putting a drop of semen onto a slide without cover slip under low magnification (100X). A rapid wave motion with formation of eddies at the end of waves indicate a good quality of semen (Zewdie *et al.*, 2005).

2.4.3. Spermatozoa motility

Motility of spermatozoa has been defined as the percentage of sperm cells that are motile under their own power and progressive motility of spermatozoa has been defined as those spermatozoa that are moving or progressing from one point to another in a more or less straight line (Bearden and Fuquary, 2000).

Spermatozoa are driven by a propulsive apparatus, the flagellum, which is equipped with contractile proteins strategically arranged in longitudinal organelles, the coarse fibers, and with associated sub filaments, and micro tubes, which provide the propulsive force necessary to overcome internal structural resistance and external viscous drag of extra cellular fluids. Estimation of motility has fundamental importance in daily quality control of semen. The percentage of motile spermatozoa is used to calculate the required degree of dilution and to estimate the number of intact spermatozoa per insemination dose. It is recommended to estimate the different forms of motility, including proportions of progressive spermatozoa (Johnson *et al*., 2000).

Sperm cells moving in a straight-line forward direction are considered in the motility measure. In order to be acceptable bull semen should have at least 70% and 40% motility respectively at the time of collection and after freezing (Zewdie *et al.*, 2005).

2.4.4. Sperm morphology

The normal morphology of spermatozoa is composed of a head and a tail that is divided into a mid-piece, main-piece, and end-piece (Bearden *et al.*, 2004). To obviate temperature shock and the assumption of spurious morphological defects, a drop of semen is mixed with two drops of Indian ink previously raised to body temperature on a warm slide. The drops are mixed and spread like a blood film. Between 200 and 300 sperms are examined and classified according to their shape and appearance. Fertile bulls show about 90 percent of the morphologically normal sperms (Bearden *et al.*, 2004). Morphological abnormalities of sperm can have a detrimental impact upon fertilization and embryonic development (Wilson-Leedy and Ingermann, 2007; Saacke, 2008).

The following morphological abnormalities can be investigated. These include: tailless sperms and sperms with looped tail, the commonest sperm abnormalities which are detachment of the sperm head and bending of the middle piece and tail around and over the sperm head (looped tails), sperms with coiled tails (this abnormality is of two types: the coil involves the extremity of the tail, or the coil, which includes the whole of the tail and sometimes the middle piece), immature or unripe sperms (these are characterized by the presence of a droplet of protoplasm at the junction of the sperm head with the middle piece at the so-called neck), abnormalities of the sperm head and cytogenic disturbances, and other defective sperms (Bearden *et al.,* 2004).

2.5. Estrus and estrus detection

Estrus has been defined as a period when the female shows characteristic sexual behavior, such as immobility, raising the hind quarters or arching the back, pricking of the ears-features that are collectively termed lordosis in small laboratory animals; mounting and riding behavior between females is also common (Bekana *et al*., 2005; GebreMedhin, 2005).

Heat detection is basic to reproductive success in artificially breeding herds, yet estrus detection rates have decreased in recent years. Reduced heat detection success tends to blamed on increased herd size and more cows per person, as well as higher milk production per cow. Higher milk production is related to negative energy balance, which occurs when cows simply cannot 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, 2010).

Worldwide there are reports that indicate low rate 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 of the artificial insemination program. This commitment is even higher in *Bos indicus* cattle, whose breeding behavior has special features of heat of short duration with a high percentage of expression during the night (Costa *et al*., 2012).

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 procedure to take advantage of the superior genetics available through AI (Graves, 2009).

2.5.1Timing of insemination

Heat detection is basic to reproductive success in artificially bred herds. A frequent question concerning AI is: What time during estrus should cows is bred for greatest chance of conception? Since estrus may last from 10-25 hours there is considerable latitude in 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).

Table 2. *Showing proper timing of insemination*

Cows showing estrus	**Should be inseminated**	**To be late for good results**
In morning	Same day	Next day
In after noon	Morning of next day or Early after noon	After 3pm next day

Source: (Webb, 2010).

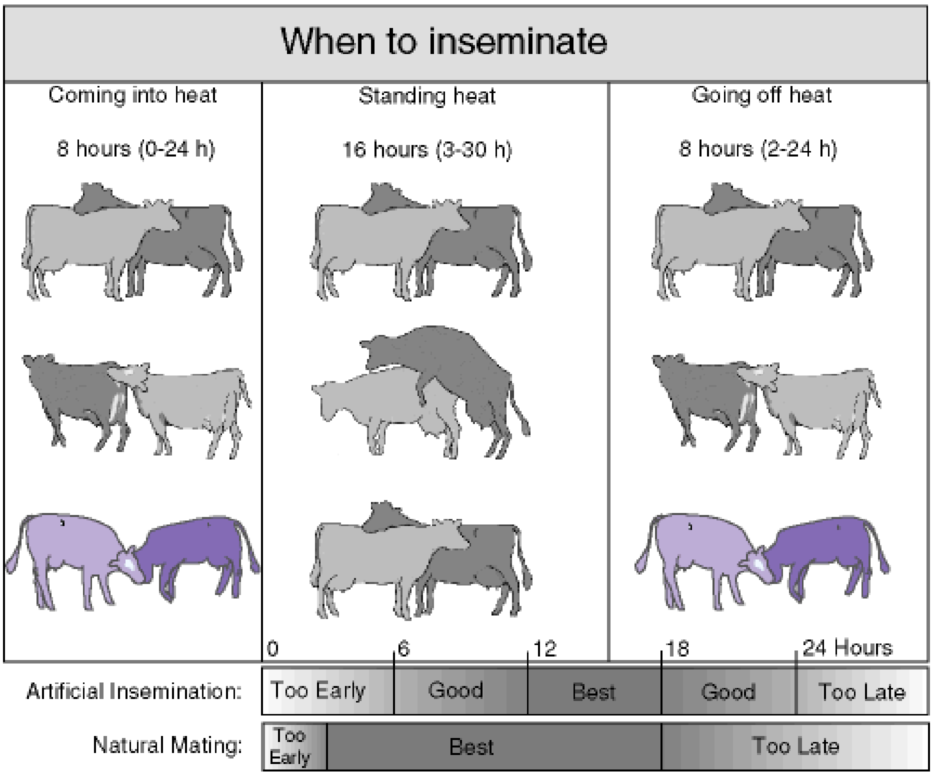

Figure 2 *Showing timing of insemination or natural service for cows in heat.*

Source: (Mikel, 2009)

2.5.2. Control of estrus

The main reasons for estrus control are: induction of estrus in lactating dairy cows that are not observed in estrus by 45 days post-partum, synchronization of groups of heifers for insemination with semen of easy calving bulls, reduction of the time necessary for estrus detection, to facilitate the use of AI under extensive conditions, synchronization of donor and recipient cattle for embryo transfer and induction of ovarian activity in beef cows with lactation anoestrus (Bekana *et al*., 2005).

Although the estrus 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 disease the most important factors affecting estral cycle appear to be the plane of nutrition, the length of the day and ambient temperature. The inadequately fed female animal grows slowly and her sexual maturity, and hence the onset of her estral cycle, is delayed. Very large numbers of tropical cattle have to subsist on low level of nutrient intake for long periods during the year. As the consequence the first effective heat periods of heifers are often delayed until they are two years or older. Environmental factors such as high temperatures decrease estrus activities. Estrus behavior was greatest in dairy cows observed twice daily when ambient temperatures were less than 25^0C compared with temperatures above 30^0C (Todd, 2012).

A combination of both visual observation and one or more of the detection aides increase the efficiency of estrus detection compared with visual observation or detection aides alone (Looper, 2000).

2.5.3. Methods of controlling estrus

In cattle with active ovaries, the estrous cycle can be manipulated by administration of prostaglandin to induce early regression of the corpus luteum (Bekana *et al.*, 2005) and by the use of progestagens that act as an artificial corpus luteum (Daris, *1998*). Synchronization of estrus and ovulation can be conducted by the use of either, PGF2α or GnRH or the combination of the two where the former is injected 7 days before the latter to induce a new follicular wave (Sugawara, 2004).

2.6. Semen Handling and Insemination Technique

The cow should be tethered and body movements restricted by crush or a person standing alongside. Excitement and stress should be avoided since adrenaline release disturbs sperm transport. When DF semen is used, insemination kits should contain a small liquid nitrogen container, a vacuum flask for hot water, a thawing flask and thermometer, gloves, tweezers, insemination guns, plastic sheaths, scissors, paper towels, soap and record books. Inseminators require protective clothing and a watch suitable for controlling thawing time (IAEA, 2005).

There must be always adequate liquid nitrogen in the tank. Preferably the tank should be kept full. Transferring of semen from the tank to the thawing water must be done quickly. Canisters should remain in the neck of the tank (Fig. 3) less than 10 seconds and preferably no longer than five seconds. Frequent opening of semen containers is to be discouraged (not more than 10 seconds in any 10 minute period). When transferring frozen straws the canister should not be brought beyond the neck of the container. It should not remain there for more than 10 seconds (Bekana *et al*., 2005).

Generally, thawing should be in warm water at 35oC for a minimum of 20-30 seconds. The straw should be wiped dry, cut at right angles and properly loaded into the insemination gun (pistolette). Prior to loading, the gun should be briskly rubbed with a piece of paper towel to warm it. This helps to prevent sudden changes in temperature which are detrimental to the semen. Faeces should be removed from the rectum. The uterus should be examined for size and consistency. Insemination must not be carried out if the uterus is enlarged (IAEA, 2005).

Figure 3. *Transferring of semen from the tank to the thawing water*

Source: (IAEA, 2005).

2.6.1. Deposition of semen in the female

There are differences between species in the site of semen deposition during natural mating. In ruminants and primates, semen is deposited in the vagina whereas in pigs, dogs, camels and horses, semen deposition is intrauterine. In most species, it is possible to pass an insemination catheter through the cervix, thus enabling semen to be deposited in the uterus during AI. Exceptions are sheep and goats, where the tightly folded nature of the cervix does not permit easy passage of an insemination catheter. The advantages of depositing the semen in the uterus are that the spermatozoa have less far to travel to reach the oviducts and fewer spermatozoa are lost through back-flow. A smaller volume of semen can be used per insemination dose than for intravaginal deposition, and the cervix, which can act as a barrier to the passage of spermatozoa, is bypassed (Milad, 2011).

Other techniques like unicornual or bicornual insemination where semen is deposited into one or both uterine horns, and intraperitoneal insemination have been investigated(Hunter, 2003). But, could not replace the transcervical intrauterine AI with semen deposition into the uterine body. For commercial AI in cattle, frozen-thawed semen is routinely used and a generally accepted insemination dose contains 10-20 x 106 spermatozoa. Deep horn AI close to the uterotubal junction has been investigated and facilitates AI with a conventional number of spermatozoa reduced x 100 or if very small volumes of semen (0.1-0.25 ml) are to be used (Lopez-Gatius, 2000).

Potential advantages of deep horn AI include: raising fertility of genetically valuable bulls whose non-return rates to estrus are sub-optimal, reducing the number of sperm per AI dose, facilitating the use of limited numbers of sex selected sperm cells available from flow cytometry, and breeding from valuable but oligospermic (too few sperm in ejaculate) bulls (Hunter, 2003).

2.7. Economic Value of Artificial Insemination

The most widely utilized technology in dairy farm is AI which widely used for the production of herd replacements. One extremely important consideration in developing reproductive technologies is the likely cost to the farmer; to a great extent, cost is likely to be determined by the scale of operations and by the experience of the organization that brings them to the farm. It might also be mentioned that there is likely to be a close correlation between management expertise in a cattle enterprise and the successful adoption of a new procedure (Gordon, 2004).

AI plays an important role to increase the yielding capacity of cows and is the appropriate and cheapest way of genetic improvement and the realization of breeding programs has to be well organized and excited in a very reliable way and AI is fully functional when it is corporated with good animal husbandry such as effective heat detection (Noakes, 2009)

It provides economical means for a livestock growers to breed their male having very desirable trait and reduce the cost of keeping bull during AI. The widespread application of AI in countries such as the USA has resulted in a steady improvement in the genetic quality of dairy animals and a doubling of milk yields during the past 30 years. In countries such as India, state governments were able to support crossbreeding programmes with the semen of exotic breeds like Holstein–Friesian, Brown Swiss and Jersey (Gordon, 2004).

2.7.1. Selection for increased yield

Improved animal production, largely as a result of genetic selection, was one of the greatest achievements of the last century (Broom, 2004). The dairy industry's goal has always been to produce quality milk for the consumer market. In many countries yield per cow has more than doubled in the last 40 years. This dramatic increase in yield per cow is due to rapid progress in genetics and management. The average energy corrected milk (ECM) yield for Swedish dairy cows increased from 4,200 to 9,000 kg between 1957 and 2003 (Oltenacu and Algers, 2005). Changes in dairy cows in Austria from 1988 to 2007 show that, the mean yield per lactation in Holsteins increased from 5,500 to 8,200 kg and in Simmentals from 4,500 to 6,600 kg (Knaus, 2009). Data from National Milk Records in the UK show an increase in average yields of dairy cows of about 200 kg per year from 1996 to 2002 and 50% of the progress in milk yield is attributed to genetics (Pryce and Veerkamp, 2001).

2.7.2. Some economic advantage of AI over natural service

Improved reproductive performance; A natural service bull's fertility, ability to detect cows in heat, and servicing capacity can vary greatly depending on the environment and season (Fricke, Paul,1997). A.I. works to eliminate that variability and get cows pregnant, on average, 3-5% faster than natural service bulls, regardless of the environment or season. A 1% increase in pregnancy rate results in approximately $35 per cow per year. With improved reproductive performance, A.I. can increase profit, on average, $105-$175 per cow per year for a dairy (Chatikobo, 2009).

Genetic advantage; The genetic dollar/cow/year advantage when using average and high net merit A.I. sires over natural service bulls for a 700-cow operation.A.I. Services and semen costs are included. Investing in high net merit A.I. sires can have an approximate 3:1economic return. Even at a moderate level of reproductive efficiency (conception rate = 35% for cows and 65% for heifers and heat detection rate = 42.5% for cows and 70% for heifers) and no synchronization programs, A.I. on average is genetically more profitable than natural service. Lowering and controlling dystocia. Calving problems will cost the dairy at calving, re-breeding and lost days of milking. A.I. provides you with the opportunity to choose sires with the specific benefit of calving ease, unlike natural service where calf size and ease of delivery are unknown. Lower Somatic Cell Count (SCC). Utilizing A.I. allows you to choose proven sires with high reliability that specialize in reducing SCC and lower mastitis in the herd to avoid the negative mastitis/reproduction effect (Josefsson and Gunnar. 2002).

2.8. Advantage and disadvantage of artificial insemination

2.8.1. Advantages of Artificial insemination

Artificial insemination is an essential technique in breeding programs with progeny testing. AI provides the opportunity to choose sires that 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 the male. It increases the selection intensity since less bull is needed and this is the basis for selection progress (Tadesse, 2010).

AI plays an important role in enhancing animal productivity, especially milk yields, in developing countries that have a well-defined breeding strategy and a sound technical base to absorb and adapt the technology to meet their needs (BBC, 2015). Daughters of AI sires produce significantly more milk than those of herd bulls sires and the income from this extra milk may cover the extra costs resulting from extended calving intervals because of low heat detection. A study indicated that daughters of AI sires were producing almost 900 kg of extra milk per lactation than daughters of natural service bulls (Valergakis *et al*, 2007). Another report from USA showed a difference of more than 1000 kg of milk per lactation on farms using AI (Smith *et al.*, 2005; Temesgen *et al., 2017*). This means that farming using AI can be more profitable apart from covering the extra costs even with calving interval of 13.5-14 months (Valergakis *et al*, 2007).

Another of the major advantages of artificial insemination is the elimination of the costs and dangers of maintaining a bull on the farm. The use of AI is the cumulative beneficial effects on dairy cows 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 decreased when AI is practiced on a dairy farm. Natural mating allows transmission of venerealy transmitting diseases like brucellosis, listerosis, leptospirosis, trichomoniasis etc between males and females (IAEA, 2005).

Some pathogens can be transmitted in semen through artificial insemination, but the collection process allows for the screening of disease agents. The progeny testing can be done at an early age. The semen of a 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 animal. It is helpful to inseminate the animals that are refusing to stands or accept the male at the time of estrus. It helps in maintaining the accurate breeding and calving records and increases the conception rate. It helps in better record keeping. Old, heavy and injured sires can be used (Johnson, 2011).

Collected semen is also routinely checked for quality, which can help avoid problems associated with male infertility (Chatikobo, 2009).

2.8.2. Disadvantage of Artificial insemination

Despite the well-known advantages of artificial insemination, a large number of dairy farmers all over the world still use natural service (NS) bulls to breed their cows. The main arguments allegedly justifying their choice are higher AI costs compared to those of keeping herd bulls and additional costs resulting from extended calving intervals because of low heat detection rates when AI is used. AI costs include; labor, equipment, liquid nitrogen, semen and three ratios of “services per conception” (Valergakis *et al*, 2007). The availability of economically priced liquid nitrogen for the cryopreservation of semen is also a particular constraint to utilize AI as a whole (FAO International Technical Conference, 2010).

Artificial insemination requires accurate time of insemination to ensure the best chances of conception. The whole reproductive success of a stud farm can be reliant on the skills of inseminators and there is room for human error. Artificial insemination 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 AI include poor conception rates due to poor heat detection, low efficiency of AI technicians and dissemination of reproductive diseases (GebreMedhin, 2005). High cost of collection, processing, storage and transport of semen, as well as budget and administrative problems and inefficiency of AI technician is also another disadvantage of AI (Desalegn, 2008).

When receiving semen from other 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 chances of cattle being larger in bred (Shehu *et al*., 2010). Artificial insemination can be limiting if the proper resources are not available, so there are some disadvantages. AI requires specialized knowledge, 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).

2.9. Status of Artificial insemination in Ethiopia

Artificial insemination, the most commonly used and valuable biotechnology has been used in Ethiopia over many decades (Webb, 2003). In Ethiopia, AI was introduced in 1938 in Asmara, which was the north part of Ethiopia, which was interrupted due to the Second World War and restarted in 1952 (Yemane, et al., 1993). 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). The technology of 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). The efficiency of AI in the country has remained at a very low level due to many constraints including; infrastructural, managerial and financial constraints and also due to technical problems such as; poor heat detection, improper timing of insemination and embryonic death. The artificial insemination program in rural bovines is greatly influenced by the status of the farmer's i.e. large marginal, small, and land less farmers (Kumar, 2005; Temesgen *et al., 2017*).

Although artificial insemination, the most commonly used and valuable biotechnology has been in operation in Ethiopia for over 30 years, the efficiency and impact of the operation has not been well-documented (Himanen and Tegegn, 1998). Reproductive problems related to crossbreed dairy cows under farmers' conditions are immense (Bekele, 2005). It is widely believed that the AI service in the country has not been successful to improve reproductive performance of dairy industry (Sinishaw, 2005).

From the previous little studies, it has been found that AI service is weak and even declining due to inconsistent service in the smallholder livestock production systems of the Ethiopian highlands (Dekeba et al., 2006). The problem is more aggravated by lack of recording scheme, wrong selection procedures, and poor management of AI bulls associated with poor motivations and skills of inseminators (GebreMedhin, 2005).

3. Conclusion and Recommendations

AI has been and still is the most used reproductive technique in animals. It revolutionized animal breeding in the 20th century, particularly in combination with sperm cryopreservation. The AI industry has developed dramatically in most domestic species in the last few decades and its use is now widespread in intensive animal production. The development of other associated technologies, such as sperm sex selection, are predicted to create powerful tools for the future, both for domestic livestock breeding and for the purposes of conservation. Artificial insemination service in Ethiopia has been given little or no emphasis at the federal, regional or Woreda levels during the last years although it is an important and the most widely practiced animal biotechnology all over the world.

Based on the above conclusions, the following points are recommended

- Governmental and nongovernmental organization should give emphasis for effective utilization and advancement of AI.
- Formal training should be given for the AI technicians to reduce insemination failures.
- Importing of semen of genetically superior sire to increase yield in the farm should be given priority for economical use of AI.
- Mechanisms should be devised to increase the involvement of stakeholders in the activities of AI in the country. The private sector should be encouraged to be involved in the AI service sector but with strict control by an active breeding policy;

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Citation: *Ahmed. M , "Artificial Insemination and its Economical Significancy in Dairy Cattle: Review ", International Journal of Research studies in Microbiology and Biotechnology, vol. 4, no. 1, p. 30-43, 2018. http://dx.doi.org/10.20431/2454-9428.0401005*