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Evaluation of Problems Associated With Artificial Insemination in Ethiopia

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Abstract

Artificial insemination (AI) is the manual placement of semen in the reproductive tract of the female by a method other than natural mating. It is one of a group of technologies commonly known as “assisted reproduction technologies” (ART), whereby offspring are generated by facilitating the meeting of gametes (spermatozoa and oocytes). ART may also involve the transfer of the products of conception to a female, for instance if fertilization has taken place *in vitro* or in another female. Artificial insemination technology maximizes animals’ productivity and produces individual sires with traits of superior quality through the use of outstanding males, disseminating superior genetic material, improvement of the rate and efficiency of genetic selection, introducing new genetic material by the import of semen rather than live animals and enables the use of frozen semen even after the donor is dead. Artificial insemination service in Ethiopia has been given little or no emphasis at the federal and regional levels for long time though it is a widely practiced animal biotechnology all over the world. The most important constraints associated to estrous synchronization in Ethiopia are: inadequate resource in terms of inputs and facilities; absence of incentives and rewards to motivate technicians; lack awareness of this technology by animal producers; shortage of feed resources; cost of semen and synthetic hormones; cost of a bull (a selftrained breeding technician), and lack of adequate transportation facilities. In general, incorporating a good management practice and selecting cows that have good body condition are the two most essential requirements for successful estrous synchronization and AI. Hence, the objective of this review is to evaluate the current status of artificial insemination; its constraints and estrous synchronization in Ethiopia.

Keywords: Cattle, Ethiopia, Fertilization, Insemination

Introduction

Agriculture (mainly crop and livestock production) is the mainstay of the Ethiopian economy employing approximately 85% of the total population. Livestock production accounts for approximately 30% of the total agricultural GDP and 16%of national foreign currency earnings (Lobago, 2007).

The total cattle population for the rural sedentary areas of Ethiopia is estimated to be 43.12 million, of which 55.41% are females. Out of the total female cattle population, only 151,344 (0.35%) and 19,263 (0.04%) heads are hybrid and exotic breeds, respectively. With an average lactation length of 6 months and an average daily milk production of 1.44 liters per cow, the total milk produced during the year 2006/07 was recorded to be 2.634 billion liters. This suggests that the total number of both exotic and hybrid female cattle produced through the crossbreeding work for many decades in the country is quite insignificant indicating unsuccessful crossbreeding work. This again suggests that Ethiopia needs to work hard on improving the work of productive and reproductive performance improvements of cattle through appropriate breeding and related activities (CSA, 2006).

In spite of the presence of large and diverse animal genetic resources, the productivity (meat and milk) of livestock remains low in many developing countries including Ethiopia for various reasons such as inadequate nutrition, poor genetic potential, inadequate animal health services, and other management related problems (Lobago, 2007). A cattle breeding is mostly uncontrolled in Ethiopia making genetic improvement difficult and an appropriate bull selection criteria have not yet been established, applied and controlled (Tegegn *et al*., 1995). Artificial insemination (AI) has been defined as a process by which sperm is collected from the male, processed, stored, and artificially introduced into the female reproductive tract for the purpose of conception. Semen is collected from the bull, deep-frozen and stored in a container with Liquid Nitrogen at a temperature of minus 196°C and made for use. Artificial insemination has become one of the most important techniques ever devised for the genetic improvement of farm animals. 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 artificial insemination (AI) service in the country has not been successful to improve reproductive performance of dairy industry (Sinishaw, 2005). From the previous, little study (Dekeba *et al*., 2006). AI service is weak and even declining due to inconsistent service in the smallholder livestock production systems of the Ethiopian highlands. The problem is more aggravated by wrong selection and management of AI bulls along with poor motivations and skills of inseminators (GebreMedhin, 2005). Hence the objective of this review is to asses and identifies the problems associated with artificial insemination services.

Literature Review

Cattle Production in Ethiopia

Ethiopia has an estimated cattle population of about 41.5 million heads. Around 99.45 are indigenous breeds with very few hybrids, 0.5%, and exotic 0.1% Cattle production together with the production of other livestock sectors has been known to be an important component of the agricultural sector. Livestock contributes much by providing meat, milk, cheese, butter, export commodities (live animals, hides and skins), draught power, manure, near-cash capital stock (EASE, 2003).

It is known that no enough selection and improvement for productivity has been performed on the indigenous cattle. Nevertheless, the indigenous cattle are known to have special merit of coping with the harsh environments of the country. On the other hand, the high performing exotic cattle cannot cope with the harsh environments of the country (MoA, 1996). Therefore, improvement on the indigenous cattle for productivity without losing traits, which are essential for survival, has been proposed (MoA, 1996).

Artificial Insemination

Artificial insemination (AI) has been defined as a process by which sperm is collected from the male, processed, stored, and artificially introduced into the female reproductive tract for the purpose of conception (Webb, 2003). 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).

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. Using the long accepted standard of 10 x 106 motile sperm at the time of insemination with an average initial motility of 60% and a 33.3% loss of sperm during freezing and thawing, the number of breeding units would entail 1 x 1012 total sperm. The author also suggested that by using sexual stimulation and more frequent collections, many sperm have been obtained from most bulls in a year without adversely affecting conception rate (Bearden *et al*., 2004).

The use of AI in Ethiopia is growing but estrus detection is difficult owing to poorly expressed estrus of Zebu breeds (Mukassa-Mugerwa *et al*., 1989). Similarly, Tegegn *et al*. (1989) and Bekele *et al*. (1991) have shown that the short duration and low intensity of estrus signs in Ethiopian Zebu cattle caused most estrus detection failures which indicates a need for the use of current advances in AI such estrus synchronization.

History of artificial insemination

The first successful AI was performein Italy in 1780 and over 100 years later, in 1890, it was used for horse breeding (Webb, 2003). In Russia, however, the method was first taken up seriously as a means of improving farm animals (Heinonen, 1989). 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. The author further indicated that Anthony Van Leeuwenhook, inventor of the microscope, first observed human spermatozoa under magnification, which led to further research. In fact, Spallanzani has been recognized as the inventor of AI. His scientific reports of 1780 have indicated successful use of AI in dogs. In 1899, Ivanoff of Russia pioneered AI research in birds, horses, cattle and sheep, and was apparently the first to successfully inseminate cattle artificially (Webb, 2003).

Mass breeding of cows via AI was first accomplished in Russia where 19,800 cows were bred in 1931 Webb (2003). Denmark was the first European country to establish an AI cooperative association in 1936. E.J. Perry of New Jersey visited the AI facilities in Denmark and established the first United States AI cooperative in 1938 at the New Jersey State College of Agriculture. The first artificial vagina (AV) was reportedly devised by G. Amantea, which was used to collect semen from the dog (Sorensen, 1979). In the years that followed, numerous Russian researchers developed artificial vagina for the bull, stallion, and ram. The method of semen collection using artificial vagina has been reported to be closest to the natural conditions and is assumed to yield the most normal ejaculate of all methods used. An attempt has been made to simulate the normal or best temperature, pressure, lubrication, and position to obtain the optimum response of the male. The AV consists of an outer rigid or semirigid support with an inner jacket containing controlled-temperature water and pressure and collecting funnel and container (Sorensen, 1979).

In Ethiopia, AI was introduced in 1938 in Asmara, the then 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 then Arsi Region, Chilalo Awraja under the Swedish International Development Agency (Sida). Zewdie *et al*. (2006) has described that 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. The efficiency of the service in the country, however, has remained at a very low level due to infrastructure, managerial, and financial constraints and also due to poor heat detection, improper timing of insemination and embryonic death.

Advantages and disadvantages of artificial insemination

The worldwide scale and importance of the artificial insemination industry in cattle breeding are beyond question (Chupin and Thibier, 1995). Maximum use of superior sires has been considered as the greatest advantage of AI while natural service has been linked to limit the use of one bull, probably, to less than 100 mating per year (Webb, 2003). The author further showed that AI usage enabled one dairy sire to provide semen for more than 60,000 services in one year. Gebremedhin (2005) has listed many advantages of AI including prevention of reproductive diseases, control of inbreeding, minimizing the cost of keeping bulls for natural service and others. Besides, the availability of accurate breeding records such as breeding dates, pregnancy rates, inter-estrus intervals, and days to first service used to monitor fertility are other advantages of AI (Sinishaw, 2005).

Artificial insemination, however, has disadvantages that include poor conception rates due to poor heat detection and inefficiency of AI technicians, dissemination of reproductive diseases and poor fertility rates if AI centers are not equipped with appropriate inputs & are not well managed (GebreMedhin, 2005). Other disadvantages include high cost of production (collection and processing), storage and transport of semen, as well as budget and administrative problems and inefficiency (Pope, 2000).

Semen Collection and Assessment of Ejaculates

Semen collection has been considered like harvesting any other farm crop (Bearden et al., 2004) since effective harvest of semen involves obtaining the maximum number of sperm of highest possible quality in each ejaculate to make maximum use of sires. This involves proper semen collection procedures used on males that are sexually stimulated and prepared. The initial quality of semen has been determined by the male and cannot be improved even with superior handling and processing methods. However, semen quality can be lowered by improper collection and the processing techniques (Bearden *et al*., 2004).

Realization of the maximum benefits of AI depends upon the collection of maximal numbers of viable sperm cells at frequent intervals from genetically superior males. The success of AI depends on the collection of a relatively large numbers of potentially fertile spermatozoa from genetically superior sires (Gebre Medhin, 2005).

Facilities needed for semen collection

The routine collection of semen for AI in dairy and beef bulls is by using artificial vagina (Faulkner and Pineda, 1980). Several essential features have been considered in designing 12 facilities for collecting semen, of which the safety of the handler and the collector have been found to be the most important in bulls in dairy farm. Safety fences, usually constructed of 7.6 cm. steel pipe with spaces large enough for a person to step through at 2.44 meters intervals, should be provided. The collection area must provide good footing to prevent slipping and injury to the male being collected. An earthen floor in the immediate collection area best provides this. Means to restrain the teaser animals to minimize lateral as well as forward movement must be provided. At the same time, easy access for semen collection must be maintained (Bearden *et al*., 2004).

Appropriate and specialized facilities, equipments, and procedures have been used during collection of semen to prevent injury to the bulls and their handlers, to maximize the physiological responsiveness of the bulls in producing semen and to enhance the quantity and the quality of the semen that can be collected. The area for semen collection has been preferred clean, relatively quiet, and free of distractions and any other stressful procedures. There has been a report of increase in spermatozoa motility by 50% through proper sexual stimulation of the bulls (Garner, 1991).

Procedure for collection of semen from the bull

Standard semen collection procedures normally include sexual stimulation, sexual preparation, and collection of the semen (Gibson *et al*., 2006). Sexual stimulation providing a stimulus situation that elicits mounting behavior in the bull is termed “Sexual Stimulation” (Herman et al., 1994). The stimulation process has been best practiced by exposing the bull to a mount animal in a collection environment and allowing to move briefly around female/teaser for a couple of minutes (Morrow *et al*., 1985).

Sexual preparation has been found to determine the intentional prolongation of sexual stimulation. It is achieved through a series of false mounts (allowing the bull to mount but not ejaculate) and restraint and ultimately results in an increase in the quantity and quality of sperm ejaculated. In dairy bulls, one false mount plus two minutes of restraint plus two additional false mounts before each ejaculation will help obtain the maximum amount of good quality semen (Gibson *et al*., 2006).

Application of Artificial Insemination

Estrus and estrus detection

Estrus has been defined as a period when the female shows characteristic sexual behavior in the presence of a mature male, 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 (Bearden et al., 2000; Bekana *et al*., 2005; GebreMedhin, 2005). Where AI or hand mating is being used, estrus detection is the most important limiting factor for optimum reproductive performance. Insufficient and/or inaccurate estrus detection leads to delayed insemination (with in estrus and post-partum), reduced conception rates and thus extended calving intervals (Bekana *et al.*, 2005).

Since the fertile life of eggs in most species is relatively short and sperm may require capacitation before they are capable of fertilizing ova, insemination should precede ovulation. Ovulation is difficult to determine routinely, so inseminations are usually related to the time of onset of estrus. Estrus in the cow is characterized by the psychic manifestation of heat. The cow may bawl frequently, is usually restless, may attempt to mount other animals, and will stand to be mounted/standing heat. The vulva is swollen and mucus is often secreted (Bekana *et al.*, 2005).

Timing of insemination

In the cow, maximum fertility has been achieved if inseminated from mid estrus to the end of estrus (Gomes, 1977). Fertilization of the ovum has been reported to occur in the oviduct at the junction of the isthmus and ampulla (Daris, 1998). The life span of the ovum is around 12 – 18 hours and its viability decreases with time. About 8 hours after service sufficient spermatozoa have reached the isthmus of the oviduct. For fertilization to take place, capacitation of the spermatozoa is required. Capacitated sperm cells show a hyper motility and have undergone the acrosome reaction. The life span of spermatozoa is limited. If insemination takes place too early, the sperm cells will die before fertilization of the ovum can occur. Conversely, when insemination is over delayed, the ovum has lost its capacity to be fertilized (Daris, 1998).

Control of estrus

The estrus cycle can be regulated pharmacologically to induce or control the time of estrus and ovulation. 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 (Morrow *et al*., 1985; Daris, 1998; Bekana et al., 2005).

Factors affecting success of artificial insemination

The site of semen deposition has been an important factor in the success of AI in cattle. In addition, the deposition of semen in the uterine body resulted in a 10% higher non-return rate than did cervical deposition. An increase in the conception rate has been reported when semen was deposited in the uterine horns rather than the uterine body (Senger et al., 1988). In contrast, no difference was found in the fertilization rate, conception rate or nonreturn rate, respectively, between uterine body and uterine horn inseminations (McKenna *et al*., 1990).

The success of AI depends upon various factors such as the efficiency, capacity and commitment of AI centers in procedurally and ethically producing, processing, handling and distributing semen; the commitments and efficiencies of AITs; presence of appropriate breeding policy along with proper control of indiscriminate crossbreeding; proper heat detections by farmers and other factors (Gebre Medhin, 2005).

Artificial insemination and fertility rates

Fertility is measured by calving rate to first service for artificially inseminated dairy cattle. Conception rate at first breeding provides a useful estimate of the conception rate for a herd. However, it is a measurement that combines the effects of semen quality, fertility of the cow, timing of insemination, semen handling and insemination techniques, as well as factors such as high environmental temperature and stress (Nebel, 2002).

In USA, conception rate of virgin heifers has been found relatively constant at approximately 65% to first service conception; whereas the first service conception rates for lactating cows has decreased approximately 33% from 60 to 40 % (Nebel, 2002). Number of services per conception as an indicator of reproductive efficiency has been defined as the number of services required for a successful conception (Shiferaw *et al*., 2003). The number of services per conception is directly related to the conception rate in the herd. Female fertility, male fertility, environmental factors, and techniques used in AI are the four general multitude factors that determine the ultimate outcome of conception per insemination. Female fertility refers to any factor directly related to the heifer/cow that may alter her probability of becoming pregnant, including condition of the reproductive tract, nutritional status, changes in body condition from calving to insemination, age, and breed (Nebel, 2002).

Male fertility cannot be controlled by the dairy producers. The mean first service conception rate for Virginia Dairy Herd Institute herds over the past 12 months in USA has been found 40 ± 13% (Nebel, 2002). There is a great reduction in fertility during the summer for lactating cows than for non-lactating heifers. High milk yield intensifies the effects of heat stress on conception and is related to increased metabolic rates and reduced thermoregulatory ability for cows with high milk yield. Techniques used in AI include accuracy of heat detection, timing of insemination, semen handling, and placement in the reproductive tract. Fertility in cattle is affected by environmental, genetic, disease, and management factors (Mukasa-Mugerwa and Tegegn, 1989).

In Ethiopia, Several factors have been reported to influence the number of services per conception. Breeding taking place during the dry season required more services per conception than the short and long rainy seasons (Swensson et al., 1981, HaileMariam et al., 1993; Negussie et al., 1998). Management factors such as accuracy of estrus detection, timing of insemination, insemination technique, semen quality, skill of pregnancy diagnosis have been reported to affect number of services per conception (Shiferaw *et al*., 2003). Higher number of services per conception might also result from repeat breeding due to infectious and/or noninfectious diseases (Bekele *et al*, 1991).

In postpartum cows, the mean number of services per conception as 2.4 and 2.7 for sub clinical endometritis positive cows, fourth and eighth weeks postpartum, respectively as compared to 1.7for sub clinical endometritis negative cows showing that sub clinical endometritis has a significant effect on number of services per conception (Bacha, 2007). This has been supposed to be due to the fact that incentives and bonuses which used to be given to AITs for each insemination resulting in conception was later stopped and subsequently resulting in increased number of services per conception. The role of incentives for inseminators is also well documented to increase reproductive efficiency (Abate, 2006).

Conclusion and Recommendation

Proper animal selection, heat detection efficiency, farmers' awareness to detect heat and on time bringing of cattle for insemination should be satisfactorily considered for effective synchronization. Generally, the overall observed efficiency of artificial insemination service under smallholder dairy cow's management system in the study area was fairly good. Hence, coverage of the AI service and the ongoing activities to improve and expand provision of liquid nitrogen and semen with appropriate exotic blood level at smallholder level in the area should be encouraged. However, shortage of feed, inadequate heat detection practices, service charge for AI, long distance from AI center, and poor management of animals are identified as major constraints of AI services in the current study.

Based on the highlighted conclusion, the following recommendations were forwarded:

✓ Great attention should be given to various factors in commencement of synchronization and AI.
✓ Successful heat detection methods and subsequent proper timing of insemination should be required in increasing conception efficiency.
✓ Further study on skill of inseminator, technique and site of semen deposition, insemination season; and on the quantity, quality and preservation of semen should also be conducted.
✓ Improving the nutritional conditions of animals selected for dairy production is of paramount importance.

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