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Estrus Synchronization and Artificial Insemination in Goats

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Abstract

Goats are small ruminants found worldwide. They provide humans with meat, milk and skin. In many rural communities, goats serve as a store of economic value and are used in cultural celebration. The world population is rapidly growing and is predicted to reach 9.6 billion by 2050. Human population explosion will exert immense pressure on the availability of food resources. Goats provide an excellent source of food to feed the world growing population. In order to increase goat population, advanced reproductive biotechnologies must be employed. These methods include and are not limited to estrus synchronization and artificial insemination. Estrus synchronization is achieved by manipulation of the estrous cycle using exogenous hormones such as progestagens, gonadotrophins, and prostaglandins. Artificial insemination can be described as all the processes involved in semen collection from a male, evaluation, processing, and eventual deposition in the vaginal of a suitable female to cause conception. Adequate knowledge about male and female reproductive anatomy and physiology is critical to the application and success of reproductive biotechnology in goat reproduction.

Keywords: estrus synchronization, artificial insemination, goats, progestagens, prostaglandin, semen

1. Introduction

Food is one of the basic necessities of life besides clothing and shelter. Animals provide a rich source of nutrients for humans. With the increasing world population and limited natural resources, many strategies to improve the reproductive capacity of domestic livestock are progressively being explored to cater for the needs of humans. Goats are hardy small ruminants that have the potential to provide meat, milk and hides [1]. Food products from goats are

a delicacy in many parts of the world. However, goats have been somewhat neglected by the research community compared with other livestock species such as cattle, poultry and sheep. Goats are hardy, have high tolerance to heat stress and can survive harsh conditions. Also, goats contribute on the preservation of the ecosystems and can be used as an ecological tool for controlling the noxious weeds, reducing the incidences of wildfire, improving the rangelands and wild life habitat [2]. In many parts of the world, goats serve as a store of wealth and are used in many cultural activities. Interestingly, the male goat is seen as a symbol of fertility. Indeed, the importance of goats in the teeming efforts to ensure regional protein sufficiency and world food security cannot be overemphasized.

Efforts to multiply goats by the application of reproductive biotechnology is on the increase especially in developed countries. In fact, goat milk is a huge industry in North America and some parts of Asia. In Africa, goat meat is considered premium meat and is associated with higher prices. Goats are important in development because of their ability to convert forages and crops and household residues into meat, fiber, skins and milk [3]. Of the different biotechnology techniques viz. multiple ovulation, in vitro fertilization, embryo transfer, etc., estrus synchronization and artificial insemination (AI) are the most powerful biotechnology tools that have hastened genetic progress and enhanced fertility in goats and farm animals [4]. Adequate understanding of these tools cannot be overemphasized and must be carefully implemented in order to ensure breeding success. Reproduction is critical to success of any livestock enterprise, including goat rearing. The objective of this mini review is to describe the use of estrus synchronization and artificial insemination techniques to enhance reproductive performance of goats.

2. Materials and methods

To achieve our stated objective, a narrative review was carried out in February 2016. The database searched was PubMed and Google search. Search terms were “estrus synchronization in goats” and “artificial insemination in goats.” A total of 301 articles were retrieved from the search out of which 146 were duplicates. These studies were carried out using different breeds of goats treated with varying hormones and protocols. Results of estrus synchronization studies carried out by the author in tropical environments were also included in the final write-up.

3. Estrus synchronization in goats

Estrus synchronization enables concentrated breeding that ensures uniform kid crop and proper management of pregnant does. Exogenous hormones are used to modify the physiological chain of events involved in the sexual cycle, while the non-hormonal methods of OS involve the use of light control or exposure to a male. In the doe, the window of opportunity is generally greater during the luteal phase, which is of longer duration and more responsive to

manipulation [5, 6]. Estrus synchronization protocols utilize several different hormones in sequence to control CL function, stimulate follicular development and regulate ovulation.

3.1. Prostaglandins and their synthetic analogues

An easy-to-apply method of estrus synchronization in goats is by the use of prostaglandins to cause luteolysis so as to induce the subsequent follicular phase of the estrous cycle. In small ruminants, prostaglandin $F_{2\alpha}$ is the primary luteolytic agent [7]. Since consumers demand food produced by “clean, green and ethical” methods [8], prostaglandins are a good alternative to progestagens. This is because prostaglandins are rapidly metabolized in the lungs and therefore, do not accumulate in tissues [9]. Prostaglandins are mainly administered intramuscularly and subcutaneously, although the intravulvo-submucosa route has been investigated with varying success. Several synthetic analogues have been used to induce rapid regression of the corpus luteum. Although natural $PGF_{2\alpha}$ causes normal luteolysis through gradual degenerative changes, synthetic analogues of $PGF_{2\alpha}$ usually have a more rapid and dramatic effect on progesterone synthesis in the lutein cells [10]. Dinoprost tromethamine marketed as Lutalyse[®] and Carboprost[®] are frequently used natural prostaglandins, while cloprostenol sodium, marketed as Fenprostamol[®], Estrumate[®] and estoPlan[®], is a synthetic prostaglandin (**Figure 1**) [11, 12]. Factors reported to affect estrus response and subsequent fertility following administration of prostaglandin or its analogues include the dose level of the prostaglandin [13], the interval between administration of the prostaglandin [14], the responsiveness of the corpus luteum to the prostaglandin/stage of the oestrus cycle [15], season and the inclusion of gonadotrophins as co-treatment [16]. Several gonadotrophins such as follicle-stimulating hormone (FSH), pregnant mare serum gonadotrophin (PMSG) and gonadotrophin-releasing hormone (GnRH) have been included in the prostaglandin protocols, resulting in improved estrus response rates. Prostaglandins should be administered from day 3 of the oestrus cycle, when the corpus luteum of the goat is responsive to $PGF_{2\alpha}$ [17].

Prostaglandins have the major advantage of being administered by intramuscular injection besides the reduction in hormonal residues, since it is rapidly and almost completely metabolized in the lungs [18]. Following prostaglandin administration, compromised follicular function has been reported leading to variability in the timing of ovulation [19]. It is essential that two injections of prostaglandin $F_{2\alpha}$ is administered 9–11 days apart. By so doing, almost all the animals would be in the mid luteal phase of the oestrus cycle and would better respond to the second treatment [20]. Double treatment with cloprostenol sodium administered i.m., 11 days apart, resulted in higher oestrus response (92.8% versus 75%) than single treatment in Red Sokoto does [21].

3.2. Progesterone and its synthetic analogues

Another method of estrus synchronization is by the use of natural progesterone impregnated in sponges, implants or silicon elastomers, or the use of its synthetic analogues such as norgestomet, fluorogestone acetate (FGA), methyacetoxypregesterone (MAP) and medroxyprogesterone acetate (MPA) [22]. The progesterone or progestagen treatment is popularly delivered though an intravaginal sponge, intramuscular or subcutaneous routes. Natural progesterone is



Figure 1. Some hormones used for estrus synchronization in goats. Hormones are mostly administered via the intramuscular, intravaginal, oral or intradermal route (picture by B.O. Omontese).

mainly marketed as Sil-Oestrus[®] implant and Eazi-Breed[®] controlled internal drug release devices[™] (CIDR) (**Figure 1**). Synthetic analogues are marketed as Chronogest[®] (Intervet, Angers, France) and Veramix sponges[®] (Pharmacia & Upjohn, Orangeville, Canada). Traditionally, intravaginal sponges are inserted over periods of 9–21 days and in most cases, eCG or PGF_{2α} is administered 2 days before at the end of pessaries removal. Factors that affect the success of an OS programme when progestagens are applied include species, breed, co-treatment, management, stage of the oestrus cycle, duration of treatment and mating system.

The use of long-term progestagen treatments has been shown to result in lowered fertility rates in goats [22]. On the other hand, decreased periods of progestagen treatment may minimize vaginal discharge and infection, and increase fertility. Currently, short-term intravaginal progestagen treatment is advocated. Following withdrawal, does usually show overt oestrus within 48 h. More recently, an alternative means of supplying continuous, exogenous progesterone has been the CIDR's, developed for sheep and goats in New Zealand. It is made from medical

silicone elastomer molded over a nylon core and impregnated with natural progesterone (330 mg). CIDRs are preferable than sponges because they are easy to use, do not cause as much discomfort as sponges and do not adhere to the vaginal wall during use. The addition of gonadotrophins to progestagen protocols ensure a tighter synchrony and/or induces a superovulatory response in treated does [8]. The use of gonadotrophins increases the cost of oestrus synchronization and is reported to reduce fertility of does in the long-term. Besides, repeated administration of eCG is reported to produce antibodies against eCG (anti-eCG), thereby causing reduced ovarian stimulation after subsequent treatments [23].

4. Artificial insemination in goats

Artificial insemination (AI) is defined as the process by which sperm are collected from the male, processed, stored and artificially introduced into the reproductive tract of a female for the purpose of conception. It is essentially the most important techniques for genetic improvement of farm animals. Although AI is most widely used for breeding dairy cattle, it is an indispensable tool for genetic improvement in small ruminants and poultry. AI has an interesting history; from the Arabian chieftain who introduced a wand of cotton into a mare's reproductive tract to collect semen in 1322 A.D., to Anthony van Leeuwenhook who first observed human spermatozoa under magnification, to Spallanzani who is described as the inventor of AI for successfully conducting AI in dogs and the Russian scientist Ivanoff who pioneered AI research in birds, horses, cattle and sheep, and was the first to successfully artificially inseminate cattle. Artificial insemination is and continues to be an essential reproductive technique for genetic purposes including creation and diffusion of genetic progress and conservation of genetic resources.

4.1. Advantages and disadvantages of AI

AI has several advantages of which the greatest is the ability to maximize superior sires for genetic improvement. AI prevents spread or exposure of sires to infectious genital diseases. In addition, bull evaluation that accompanies AI enables early detection of infertile bulls, eliminated handling of stubborn bulls and allows use of bulls unable to mount due to foot injuries. Importantly AI also helps ensure that accurate breeding records can be kept. As with many scientific techniques, the disadvantages of AI include increased cost associated with labor and facilities. In addition, AI only allows utilization of a few sires, which reduces genetic base. Also, there is potential for rapid spread of undesirable traits, if bucks from which semen is sourced are not carefully evaluated, hence, if the buck had a genetic defect this will be widely spread in the population. Therefore optimum care and critical evaluation of semen from bucks to be used for artificial insemination is of paramount importance.

4.2. Collection, extension and storage of semen

For AI to be successful, quality semen must be used. The quality of semen is determined by proper collection, extension and storage. Several methods of obtaining semen have been

developed but the most popular method in goats is the use of electro ejaculator and artificial vagina. The later method, which gives the best quality, requires that the stud properly stimulated and then allowed to mount a teaser doe and ejaculates when the penis is directed into the artificial vagina. When an electroejaculator is used, rhythmic stimulation of the ampullae, accessory sex organs and the sacral nerve plexus cause erection and ejaculation. Semen should be evaluated for mass motility, individual progressive motility, volume, pH, ejaculate concentration and morphology. It is important that a strict sense of hygiene is maintained during the process of semen collection, processing and storage. Diluting/extending semen increases the volume and helps to increase the number of females serviced from one ejaculation as a normal ejaculate from a buck varies from 2 to 6.5×10 sperm/ml. Examples of commercially available semen extenders are sodium citrate diluent, Tris diluent, Cornell Union Extender, egg yolk-phosphate [24]. Other non-conventional extenders include homogenized milk-fructose, homogenized whole milk-phosphate, Tris-coconut milk and coconut milk citrate [25]. Cryoprotectant glycerol, and antibiotics such as penicillin and streptomycin are added to semen extenders to inhibit bacterial growth [26]. Semen is stored for short term or long term depending on when it should be used. It can be refrigerated ($+4^{\circ}\text{C}$) for short term or in liquid nitrogen for long term (-96°C). Semen stored in liquid nitrogen can be viable for decades with limited deterioration in fertility.

4.3. Insemination technique

There are three methods of inseminating goats; intracervical, intrauterine (difficult), or laparoscopic insemination. For fertility to be optimum, semen must be deposited in the appropriate place in the reproductive tract of the female and at the right time (when a female is in estrus). In does, semen may be deposited in the vagina but the best location to optimize fertility is when semen is deposited in the inner cervix. Insemination in does requires the use of an insemination gun, pipette and vaginal speculum. AI guns are also referred to as pistolettes. There are three sizes of AI guns; 0.25 cc, 0.5 cc and Universal. A loaded AI gun consists of a plunger which forces a plug through the straw to expel semen, a barrel which houses the semen straw, disposable plastic sleeve (sock or sheath)—to keep the semen straw in place, semen straw and an O-ring-to maintain the inseminating sheath in place. Does must be restrained; vulva should be cleaned before inserting the inseminating gun. Semen should be slowly deposited near the uterine end of the cervix or just inside the uterus. The ease of inseminating goats varies, as it is simpler with older, multiparous does with larger and less convoluted cervix compared with younger does with smaller and highly convoluted cervix.

5. Conclusion

Goats continue to provide of nutritional, economic and social benefits. Reproductive biotechnologies should be adopted to improve the overall efficiency of goat production systems. Estrus synchronization and artificial insemination continue to be essential reproductive techniques for genetic creation, diffusion and conservation of genetic resources.

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