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Chapter 5

Reproduction in Goats

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Additional information is available at the end of the chapter

http://dx.doi.org/10.5772/intechopen.70003

Abstract

Reproductive activity of the goat begins when the females reach puberty, which happens at 5 months of age. The ovarian or estrous cycle is the period between two consecutive estrus. It is also the time that lasts the development of the follicle in the ovary, until rupture occurs and ovulation takes place, which coincides with the appearance of estrus. This chapter will describe the physiological and endocrinological bases of estrus in the goat. Likewise, factors affecting the presence of estrus and ovulation will be described. At another point, synchronization of estrus and ovulation, factors affecting the presence of estrus and external symptoms of estrus, will be described. To achieve synchronization of estrus or induction of ovulation within or outside the breeding season, it may be necessary to manage light hours, male effect, and/or use of hormones. The importance of artificial insemination is described, as well as the current situation of this technique worldwide. Currently, the techniques of artificial insemination in goats have been limited worldwide, due to the lack of resources of producers and trained technicians. The techniques of artificial insemination with estrous synchronization programs and ovulation with current research results will be described.

Keywords: goats reproduction, estrual cycle, estrous synchronization, artificial insemination

1. Introduction

Since its domestication, the goat has been characterized by being seasonal polyestrous, that is, during certain times of the year, it reproduces naturally. This characteristic varies mainly according to the hours of daylight (photoperiod), rasse, and nutrition [1]. It is mentioned that

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the more goat is exploited at latitudes more distant from the equator, the breeding season will be shorter [2]. However, in latitudes nearer from the equator, the presence of estrus will depend on the availability of nutrients and the environment. On average, the goat's estrus cycle is 21 days, and the high frequency of short estrual cycle is characteristic and tends to occur at the beginning of the reproductive season and in young animals [1, 2]. The average duration of standing estrus is 36 hours but can range from 24 to 48 hours depending on age, breed, season, and presence of a male [3].

2. Folliculogenesis

In mammals, germ cells originate from the extraembryonic endoderm and migrate by amoeboid movement into the coelomic cavity, to reach the urogenital mesodermal crest. Subsequently, the germ cell is transformed into oogonium, which should populate the gonad by mitotic processes. At the end of mitosis, the oogonium enters the meiotic cycle until prophase I, where it acquires the primary oocyte state [4]. Therefore, folliculogenesis begins when the primordial follicle is formed, due to the union of the primary oocyte and granulosa cells. In primordial follicles, the primary oocytes leave their state of latency spontaneously and continue to other phases of growth during which the differentiation and proliferation of the oocyte coexist with the surrounding cells and by the effect of the growth factors synthesized in the microenvironment ovarian; all these events are independent of the gonadotropins [5]. Different types of follicles are present during folliculogenesis. Primordial follicle: This follicle begins the process of follicular growth and maturation, to guarantee increasingly mature units that can lead the ovary toward ovulation or atresia. Primary follicle: It is characterized by a significant change occurring when the flattened cells surrounding the oocyte increase in size into a more cuboidal form, grow in diameter, and consolidate as a structure with oocytes having a diameter greater than 22.12 mm and a layer of 25–40 cuboidal cells called granulosa cells. It also increases the volume of the oocyte and the formation of the zona pellucida. Secondary follicle: The transition to this stage depends on the FSH stimulus. At this stage, granulosa cells develop the ability to synthesize growth factors and steroids [5].

3. Physiology and endocrinology of the estrual cycle of the goat

The ovarian cycle is classically divided into two phases: follicular phase and luteal phase (**Figure 1**). The follicular phase corresponds to the wave of follicular development that will provide the ovulatory follicle and involves the maturation of follicles that are dependent on the gonadotropins until ovulation [6]. During the follicular phase, FSH secreted by the anterior pituitary stimulates follicular growth. A cohort of antral follicles, which are gonadotropin dependent and with a diameter of 2–3 mm, is recruited, and the follicles enter their

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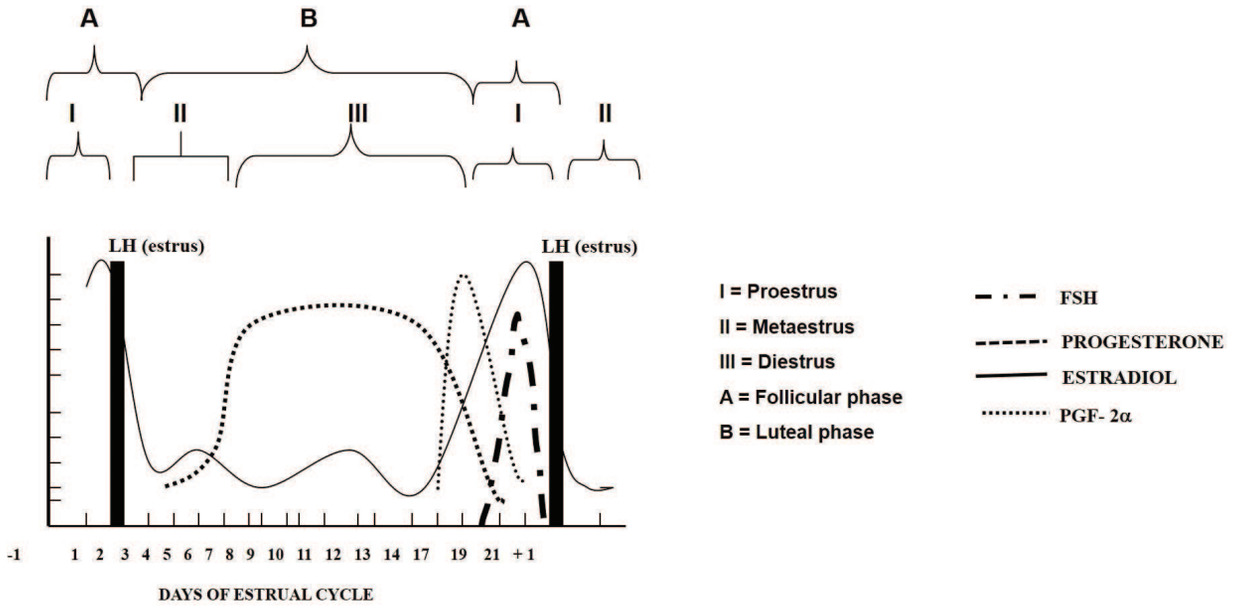


Figure 1. Schematic representation of the estrual cycle of the goat (modified by Fatet et al. [3]).

terminal phase of growth [7]. Only two to three of these follicles reach a size of 4 mm in diameter and are selected to enter the dominance phase. Under the influence of LH, the follicles reach the preovulatory stage (6–9 mm), while the subordinate follicles degenerate (follicular atresia). The increase in the peripheral concentrations of estradiol 17β causes a positive feedback effect on the hypophysis-gonadotropin axis, due to the follicular growth inducing the goat's estrus behavior [8]. The consequent increase in gonadotropin-releasing hormone (GnRH) secretion induces an increase in the preovulatory LH peak, which will induce ovulation between 20 and 26 hours later, and finally the luteinization of follicular cells will occur. The beginning of the follicular phase, before the estrual behavior is observed, is known as proestrus. The estrus phase includes the events of the sexual behavior of the goat until ovulation. Consequently, a response to estrus and ovulation will mainly depend on the time of pregnancy and nutrition. Whereas providing the goat with short energy supplementation can increase the rate of ovulation. During the estrus cycle, the ovaries undergo a series of morphological (follicular recruitment and growth), biochemical (follicle maturation), and physiological (endocrine regulation) changes, which lead to ovulation. These cyclic changes that take place in the gonads are known as ovarian cycles. For follicular growth, it develops in the form of waves throughout the cycle (**Figure 1**). A follicular wave is characterized by the sequence of three gonadotropin-dependent events: recruitment, selection, and dominance. When performing repeated ultrasound studies, one can mention and/or suggest that there are between two and six waves of follicular development during the estrus cycle; in goats, there are usually three–four waves. The last follicular wave is the one that is going to give rise to the ovulatory follicle. When double ovulations occur, they are due to follicles derived from the same wave but two consecutive follicular waves [8, 9].

Also, the luteal phase begins when the corpus luteum is formed after follicle luteinization (duration 16 days). During this phase, LH is released pulsatile and, its frequency is negatively correlated with progesterone. Now, progesterone has a negative feedback effect on LH. Luteolysis begins around day 16–17 of the estrus cycle, releasing uterine prostaglandins, influenced by oxytocin. With the above, the concentration of progesterone decreases, causing a strong increase in the frequency of pulses of LH and its amplitude, which causes ovulation [10].

3.1. Extern symptom of the estrus

The external symptoms of estrus that can be mentioned as important are goats move the tail, increase vocalizations, decrease appetite, mount between them, increase urine excretion, inflammation of the vulva, and discharge of vaginal mucus.

4. Estrous synchronization and induction of ovulation in goats

Globally, the goat was one of the first ruminants to be domesticated more than 10,000 years in Asia. It has been one of the most useful species to man as a supplier of meat, milk, skin, and fibers for families. By 2014, there was a world population of 1011 million heads of goats. A goat has always been considered a family subsistence animal; however, the interest of developed countries to organic food changed the way to exploit it more technically. Fortunately, there has been a change in this attitude, and more recently producers in developed countries have become interested in exploiting goats for their attributes, such as adaptation to adverse climatic conditions, increased meat production, and early slaughter age [11, 12].

At the beginning of the twenty-first century, one of the reproductive tools that has had great impetus in research has been the synchronization of estrus. This technique aims to concentrate the estrus of the goats at different times of the year. Synchronization of estrus involves the development of a luteal phase by means of exogenous hormones (devices with natural or synthetic progesterone) for a specific period and not exceeding the luteal phase of the normal goat cycle [13].

With this technology, farmers can use more efficiently complementary techniques for reproductive management, including artificial insemination (AI) and multiple ovulation and embryo transfer (MOET), such that genetic material is more easily obtained or transferred domestically and internationally [14]. Exogenous hormones are used to modify the physiological chain of events involved in the sexual cycle, while the nonhormonal methods of estrous synchronization involve the use of light control or exposure to a male [15]. In the doe, the window of opportunity is generally greater during the luteal phase, which is of longer duration and more responsive to manipulation. It is essential that any estrous synchronization technique should not only establish synchrony but also ensure reasonable levels of fertility in the synchronized cycle [15].

4.1. Current status of estrous synchronization programs in goats

In goats, estrous synchronization protocols are currently based on the use of vaginal devices (sponges) impregnated with 20–40 mg of fluorogestone acetate or 50–60 mg of

medroxyprogesterone. In the 1980s, controlled internal drug releasing (CIDR) began to be used, which is an inert silicone elastomer containing 0.3 g of natural progesterone (P4) [16]. These devices are inserted intravaginally for a period of 5–14 days (see **Figure 2**) to create a luteal phase and then accompany it with a luteolytic agent, as well as the application of a hormone that synchronizes ovulation (equine chorionic gonadotropin (eCG), estradiol benzoate (EB), gonadotropin-releasing hormone (GnRH)), which have been applied at the time, 24 and 36 hours to remove the device, respectively [17, 18].

4.1.1. Prostaglandin-based synchronization

Prostaglandin F2α (PGF2α) and its analogues have also been used to synchronize estrus by controlling luteal function since PGF2α was discovered to have a luteolytic effect in sheep. During the estrous cycle, PGF2α is secreted by the nonpregnant uterus to 16 days after estrus [5]. Administration of PGF2α after removal of a CIDR mimics the secretion of PGF2α by the uterus, causing lysis of the CL and the onset of a new follicular phase [18]. Administration of PGF2α is effective from approximately d 3 to d 14 of the estrous cycle in sheep [19]. Analogues of prostaglandins can also induce luteolysis and are often more cost-effective. The effectiveness of PGF2α is limited to the active period of cyclicity in small ruminants. The lack of ovulation of the follicle during seasonal anestrous causes a lack of luteal development [19]. A single administration of PGF2α can induce luteolysis, and two PGF2α injections at an interval of 10–12 days have been used to synchronize estrus (see **Figure 3**). These treatments can be used on cycling goats only, limiting its application during the extended periods with nonfunctional corpora lutea [20].

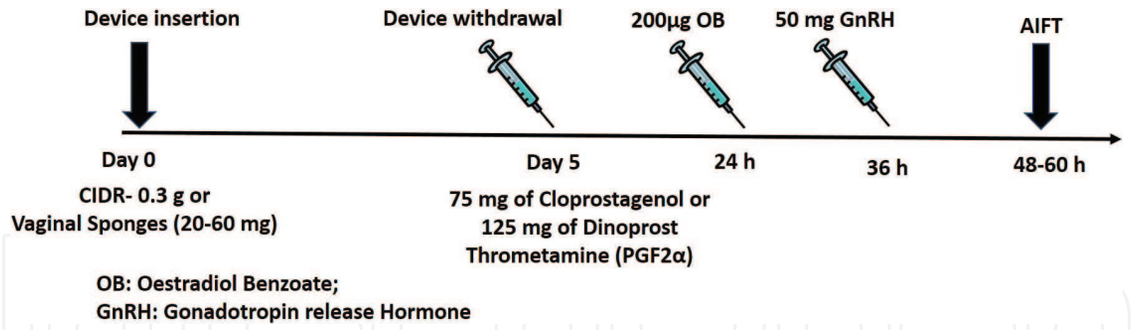


Figure 2. Short protocol at 5 days and ovulation synchronization with OB or GnRH.

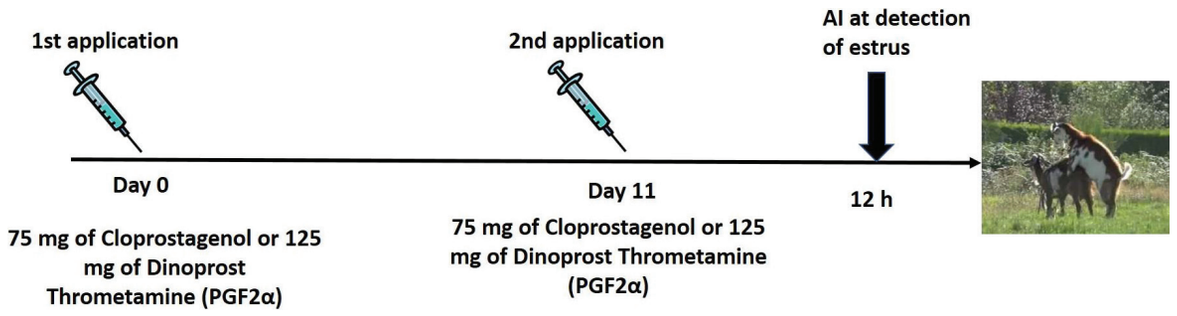


Figure 3. Protocol of synchronization of estrus with prostaglandins within the reproductive season.

Because of the use of PFG2α in the synchronization of estrus within the reproductive season, up to 70% of estrus goats have been obtained. These results are lower than those reported when using different devices with progesterone source [21]. On the other hand, in temperate and subtropical regions, the use of the male effect is a tool that is increasingly being used to avoid using hormones, with a 60% effectiveness in the presence of estrus and ovulation in the first 5 days after the introduction of males. In goat herds, it is important to emphasize that the effect of nutrition plays a preponderant role in the synchronization programs of estrus and ovulation using hormones and male effect or a combination of both within a reproductive program to use AI [22].

4.1.2. Progesterone-based synchronization

The synchronization of estrus in goats by medroxyprogesterone acetate (MAP) or fluorogestone acetate (FGA) sponges has been accomplished in many advanced countries in the world [22]. Most commonly, progestogen-/progesterone-impregnated vaginal devices and subcutaneous progestogen implants followed by an injection of equine chorionic gonadotropin ((eCG), formerly PMSG), were used for estrous synchronization [23]. However, a prolonged progestagen treatment is also associated to reduced fertility (related to a subluteal serum progesterone concentration at the end of treatment) [24]. This acts by promoting the growing and persistence of the dominant follicle which causes detrimental effects on fertility. Reduced fertility in prolonged progestagen-treated females may be also related to an impairment of sperm transport in the genital tract [23, 24].

Intravaginal sponges impregnated with progestogens have been extensively used in sheep and goats to control estrus and ovulation during the breeding and non-breeding season. One of the main problems associated with controlled breeding is the estimation of the time and degree of estrous response. Thus, if one can predetermine the time from withdrawal to onset of estrus, the need for estrous detection could be reduced or even eliminated. In goats, fluorogestone acetate (FGA) and medroxyprogesterone acetate (MAP) sponges have been found to be equally effective in estrous synchronization (see **Figure 4**) [25].

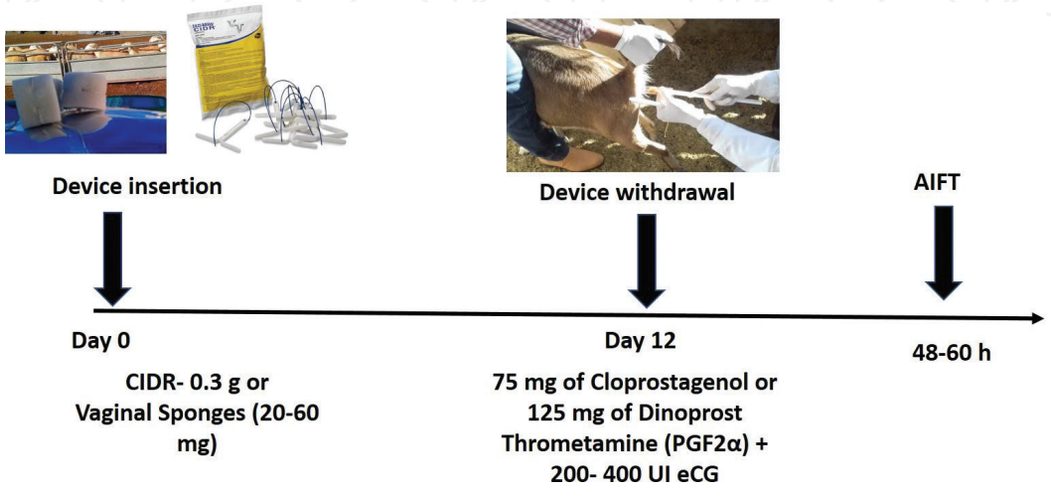


Figure 4. Normal protocol of estrous synchronization.

4.1.2.1. Combined CIDR and PGF synchronization

Research protocols for CIDR inserts have been focused on short-term (5–7 days) and long-term (12–19 days) length in small ruminants [26]. One of the benefits to short-term progesterone protocols is the ability to synchronize females in a short period. This can be beneficial to producers in planning timed AI or ET programs. Short-term protocols typically combine the use of progesterone with multiple follicle-controlling hormones, such as follicle stimulating/ovulation inducing, a combination of equine chorionic gonadotropin (eCG), human chorionic gonadotropin (hCG), and PGF2α [26]. Using multiple hormonal controls in short-term synchronization protocols gives an increased ability to control luteal and follicular dynamics (see **Figure 4**) [10]. Previous research indicates that serum progesterone concentrations are maintained at an increased level when compared with a long-term progesterone insert protocol [27]. The label recommended protocol for CIDR insert in ewes is 5 days and has been proven to induce ewes and does exhibit estrus during active cyclicity and during anestrous (see **Figure 5**) [1]. Concerns with short-term CIDR protocols include inconsistency in estrus response and increased interval to estrus [27]. Estrus cannot be precisely predicted, and the interval from CIDR removal to estrus can range from 35 to 70 **subsistence** ours [25]. Long-term synchronization protocols in sheep and goats have proven to result in shorter intervals from CIDR removal to estrus when compared with short-term protocols [27].

CIDR devices offer important advantages. Firstly, they contain low natural doses of progesterone [27]. Moreover, unlike intravaginal sponges, CIDRs do not absorb or obstruct drainage of vaginal secretions, resulting in less foul-smelling discharge upon removal. Finally, these devices also induce earlier and more compact synchronization and have a better retention rate during treatment [28]. However, CIDRs are expensive when the benefit/cost ratio is evaluated and compared to vaginal sponges. For this reason, the reuse of CIDR up to 3 times has been expanded in sheep as in goats to reduce the costs of estrous synchronization programs and therefore use more artificial insemination in both species [29].

4.1.3. Male effect

The "male effect" has been a subject of research for nearly 75 years, which began to be published in the first scientific articles in sheep (1944). The male effect is defined as an interaction between

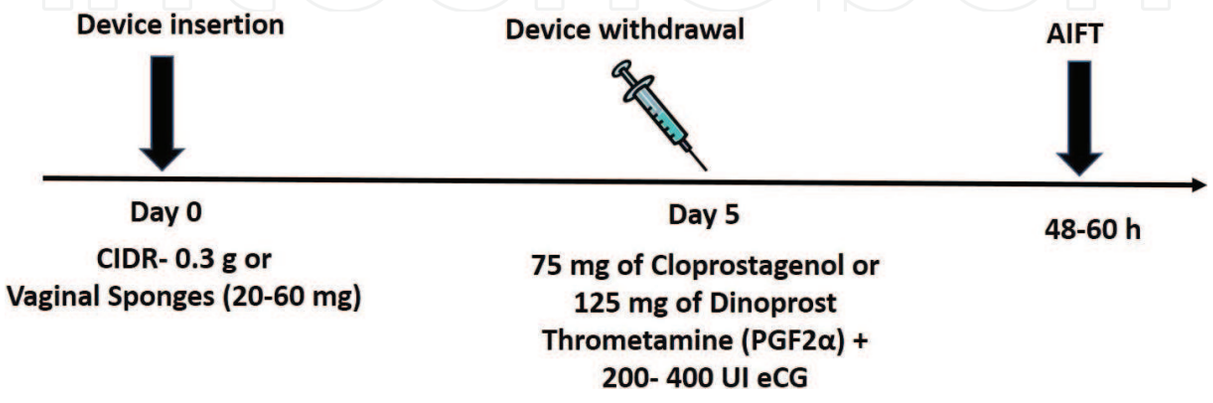


Figure 5. Short protocol of 5 days and artificial insemination at fixed time (AIFT).

a male and a group of females at the time of starting a mating. Physiologically, the contact of a group of goats in anestrous with males induces an increase in the frequency of LH, which gives rise to a preovulatory peak and consequently ovulation before 48 hours (see **Figure 6**). Also, it has been clearly established that the first ovulatory cycle is sometimes accompanied by estrus, although the first estrus is detected until the second ovulation (7–14 days) after the introduction of the males [29, 30]. The recent concept of production described as the "clean, green, and ethical" method seeks to find natural alternatives to achieve the same objective of improved reproductive rates by natural means [31]. However, the male effect should be accompanied by good management practices, animal health and especially nutrition. Recent studies have shown that goats that present subnutrition at the time of introducing the male (energy deficit) present a delayed response up to 7 days to present the first estrus with ovulation compared to goats that have covered the energy requirements during the breeding season. Furthermore, the male response will have a better impact on goats that have a body condition below 2 compared to goats that have a body condition above 3. Within this context, the male effect on dairy goats has also been evaluated, where the presence of estrus occurs later compared to the breeds of meat, where the period of breeding is extended by 31 days more [31]. The presence of bucks creates olfactory, behavioral, and visual stimuli which in an increase in the secretion of luteinizing hormone which stimulates folliculogenesis and ovulation [10]. Although it was initially believed that pheromones played a pivotal role in the male effect, subsequent work has proved that visual and behavioral stimuli are equally as important as the smell [31].

In recent years Delgadillo and Martin [2] published and confirmed that many of the dogmas related to the male effect are not true. For example, they concluded that in goats it is not necessary to fully shear the males, even to the extent that the wind is directed in the herd. On the other hand, the sheeps recognize the new sheep and respond to them without any problem when they join with the sheep in the herd. Likewise, they report that the male effect is minimal in cyclic goats. As it was also mentioned that after the introduction of the male, it should remain permanently in contact with the goats; it is now confirmed that with only 4 hours of contact, this phenomenon occurs. However, in sheep that present a deep seasonal anestrous, they respond to the male effect that is sexually active. To achieve this, a treatment based on a light program (photoperiod) + melatonin implants can be provided, or in bucks, the application

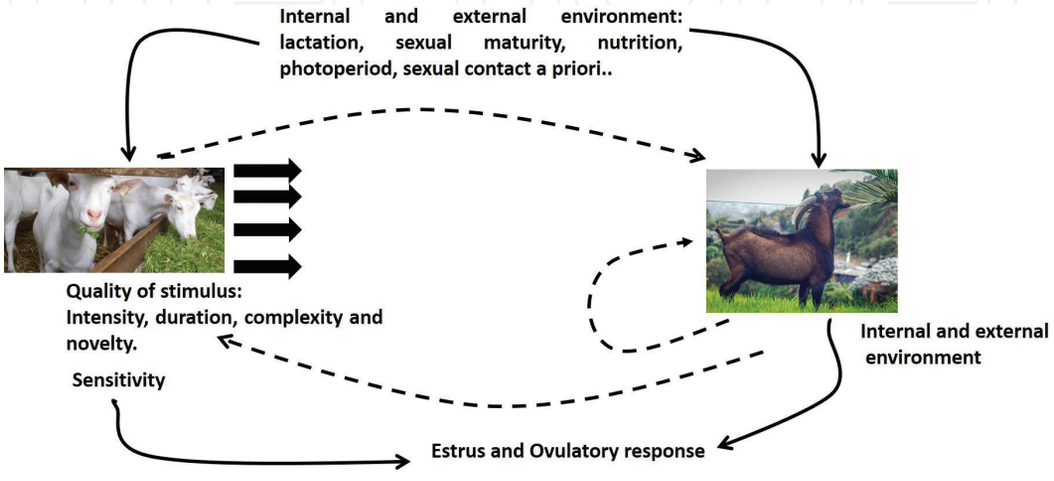


Figure 6. Schematic representation of "male effect," modified from Delgadillo et al. [1].

of testosterone 1 month before male introduction (10 mg/day 3/3 weeks). Likewise, for the goat to respond to this phenomenon, it is necessary the complete contact of both sexes and not only by the smell of the male [31].

4.1.4. Synchronization and induction of ovulation

The use of eCG after progestogen exposure to promote ovulatory follicular growth and ovulation is inquired as repeated eCG treatment is known to affect pregnancy rate in goats [31]. This detrimental effect is associated with an immunogenic response induced by repeated eCG treatment, which is frequent in goats under intensive breeding programs [24]. It can also be used to synchronize ovulation, administering 50 mg of GnRH 36 hours after the removal of the device [31] or 200 μg of estradiol benzoate given 24 hours after the short-term protocol (see **Figure 2**) [32].

Estrous synchronization protocols have been improved to more frequently use fixed-time artificial insemination as well as more effectively implementing third-generation reproductive techniques. These are oocyte production in vitro, cytoplasmic sperm injection, nuclear somatic cell transfer, and pronuclear microinjection of zygotes. At present, additional research is required to lead to an economical and efficient synchronization program to establish efficient protocols for controlled breeding, massive use AI, and embryo transfer by nonsurgical methods [32].

4.1.5. Factors affecting estrous synchronization programs

Various factors affecting synchronization program have been reported, but the genetic and environmental factors (animal breed, photoperiod, temperature, etc.) were shown to be of primary importance in most of the studies [9–11, 33]. Controversial synchronization estrus results (from 40 to 100%) have been determined in dairy goats with artificial insemination by several authors [19, 20, 26]. In most of the experiments, different factors (season, breed, age and body condition score of the animals, estrous synchronization protocol, time and number of AI, and the breeding technology) have been shown as a cause for varying results [33].

4.1.6. Nutrition and body condition

Numerous studies confirm that nutritional management significantly affects goat breeding. When the goats are to be reproduced, one factor that negatively affects the response to the presence of estrus and ovulation rate is body condition. Thus, recent studies have shown that when goats have a body condition below 2, ovulation rate is reduced by up to 16% compared to goats with body condition above 3. In addition, goats with low body condition present a shorter breeding season and estrus cycles of abnormal duration [33]. However, research carried out in recent years shows strong results that, when supplementing goats with low body condition (2), have a higher rate of ovulation (37.5%). Studies carried out in goat grazing confirm that the goats lose their body condition in one unit or more; they present a smaller and more prolonged "response" to the male effect, besides a poor rate of ovulation and of births. Physiologically, in goats, the follicular population is very sensitive to the entry of nutrients, so that folliculogenesis and ovulatory rate can present a favorable response through the supplementation, being monitored the nutritional status through the body condition [34]. In addition, deficient nutrition affects ovulatory cycles, where underfed goats exhibit increased

sensitivity of the pituitary to negative feedback of estradiol, which causes an inhibition of GnRH release and therefore LH. Likewise, in sheep, it has been found that the feeding level determines the live weight and the body condition, presenting a static, dynamic, or acute effect of the nutrition on the ovulatory rate, which depends on the observed changes in live weight and body condition. The "acute effect" is the one that has been given more attention in current research to promote significant changes in follicular population and ovulation rate, without the need to present changes in live weight and body condition [34]. For the above, "flushing" overfeeding strategies have been used, which consist of increasing the energy or protein levels of the goats before and during the breeding, to positively affect the rate of ovulation and prolificacy. Alternatively, it is possible to maintain this nutritional practice 10–15 days after the breeding to contribute to the implantation of the embryo, reducing the early embryonic mortality. Recent studies confirm that goats with a body condition less than 3 respond better than others with greater body condition. Also, it is defined that the changes in the ovulatory rate that receive high levels of feeding positively affect a glucose increase at the cellular level. This implies that glucose participates in the control of ovarian function, where the levels are regulated by insulin, which plays an important role in follicular growth in goats [35].

However, assessment of body condition is a simple indicator of body fat reserves, which can be used by the goat in periods with high energy demand, stress, or undernutrition. Likewise, body condition values have been determined from 1 to 5, where 1 is skinny and 5 is obese. It has been evaluated that the goats must maintain a body condition of 3 so that the reproduction is not affected negatively; here, the visual aspect of the goat would be the backbone is not prominent, ribs are barely discernible, and an even layer of fat covers them. Intercostal spaces are felt using pressure [35].

Dairy goats with excessive fat reserves or over-condition at kidding may have a greater risk of lower milk yield and of increased health and reproductive disorders (see **Figure 1**), such as dystocia and fatty liver. According to Ref. [35], animals with extremely good body condition tend not to respond to flushing.

Reproductive seasonality limits the reproductive efficiency in goat production systems. This seasonal reproductive pattern evolved in goats in a manner that time of parturition and lactation coincides with season of the greatest feed availability and favorable temperatures. In domestic goats, reproductive season starts between the summer and fall and ends between the winter and spring, depending on both breed and geographic latitude [36].

5. Artificial insemination

Artificial insemination (AI) is an important technology for improving animal production. Through consistent use of AI, herd genetics can be advanced at a rapid rate. While AI is a technology that enables the dissemination of selected male genetics, embryo transfer (ET) is a technology that enables the dissemination of selected female genetics, and, by using ET, frozen embryos can be moved around the world at significantly reduced costs compared to movement of adult animals [37]. Utilization of either AI or ET requires careful doe management and is most effective when these technologies are used in conjunction with estrus or

ovulation synchronization. Artificial insemination (AI) involves collection of semen from a buck and transfer of the semen to the reproductive tract of the doe. Does can be inseminated either with fresh semen or with commercially available frozen semen [38].

Other authors mention that AI allows producers to use superior bucks to dramatically improve performance of their herd [38]. However, the rewards of AI depend on sound management. Artificial insemination in goats is more difficult than it is in cattle because of the small size of the animal and the complex anatomy of the cervix, making insemination into the uterus difficult. Advantages of the AI are the following:

1. Genetic improvement via buck
2. Easy transport and introduction of genetic material at the global level
3. Extended semen conservation of genetically superior chives
4. Control of diseases transmitted by natural mountain (up to certain point)
5. Lower inventory of bucks in the herd

The success of AI is dependent on:

1. The appropriate timing of insemination in relation to estrus and ovulation
2. The ability to efficiently collect and cryopreserve (freeze) sperm from quality bucks
3. The seasonality of goat's reproduction

5.1. Techniques of artificial insemination

5.1.1. Artificial insemination transcervical

The cervix of the doe has four tightly closed, cartilaginous rings that provide structure to the cervix and, along with cervical mucus, form a protective physical barrier against the entry of foreign particles. To achieve the highest pregnancy rates for AI, semen must be deposited into the uterine body or into each of the uterine horns. Deposition of semen into the uterus requires that all four cervical rings must be passed during the insemination procedure. The small size of the doe's reproductive tract, particularly for nulliparous (virgin) or young primiparous (once kidded) does, in addition to the tightness of the cervical rings and their typical lack of alignment, can make passing the insemination rod during transcervical AI a challenging task. However, several methods for transcervical insemination have been developed and are available [38], some of which are similar to procedures described for nonsurgical embryo transfer in goats [38].

5.1.2. Standard AI method (tube speculum)

The simplest transcervical AI method involves the use of a tubelike speculum and a standard French-style insemination gun. The speculum, with a detachable light, is inserted into the vaginal vault of the doe and used to visualize the external cervical which is the entry point

into the cervical channel [39]. Frozen semen is available in 1/4cc or 1/2cc straws and must be appropriately thawed prior to use. Once the semen straw is prepared and placed into the insemination gun, a clean sheath is overlaid to protect the semen and reduce cross contamination between does. Sheaths can have either standard (rounded) or apex (pointed) ends that can aid in achieving deeper penetration of the cervix [40]. The insemination gun is introduced through the speculum, and the inseminator attempts to pass the insemination gun through the cervix and deposit the semen into the uterine body. Following insemination, the gun and speculum are removed and the speculum disinfected between does. The single-use AI gun sheath is disposed appropriately. The major advantage of the standard method is that it is a simple and easily mastered technique that is reasonably effective with older, multiparous does (see **Photo 1**). The major disadvantage of this technique is that it is difficult to pass the insemination gun through the small cervix of a young doe or through the cervix if it is highly convoluted. In many cases, the use of the standard technique results in deposition of the semen in the cervix if all the cervical rings cannot be passed. Under controlled conditions, pregnancy rates following the use of the standard technique are low, typically in the range of 20–30% [41–44].

5.1.3. Deep cornual (uterine) insemination (catheter-within-catheter) method

In 2005, the development of a novel method for transcervical insemination of goats has been reported. In their method, semen is deposited deep into the uterine horn (cornua) by means of a catheter-within-catheter technique. This technique relies on the use of a soft, small diameter pediatric urinary catheter stiffened with an insemination gun stylet to enter



Photo 1. Student of agronomy practicing the transcervical artificial insemination in goats.

the uterine body and individual uterine horn. To facilitate passage through the cervix, the doe's hindquarters are raised, and a Pozzi Tenaculum Forceps are used to grasp the cervix and align the cervical rings. Once the catheter is positioned into the uterine horn, the stylet is removed, and a small diameter insemination tubing is threaded through the urinary catheter and used to deposit fresh or frozen-thawed semen into the upper portion of the uterine horn. The urinary catheter is then repositioned into the opposite uterine horn, and the second half of the semen sample is deposited deep into that horn to complete the insemination. With trained technicians, the entire procedure takes about 5–10 min [41] and does not involve any surgical entry or anesthesia of the doe. Furthermore, pregnancy rates following deep cornual insemination were greater than those for laparoscopic insemination in their study. In a subsequent study, pregnancy rates using ovulation synchronization with TAI of a single dose of frozen semen were 58% and kidding rates similar at 53%. These pregnancy rates are comparable to those obtained for beef cattle for first-service insemination after TAI using frozen semen [45].

5.1.4. Artificial insemination by laparoscopy

Currently, artificial insemination techniques in goats and sheep have been limited globally due, among other factors, to the lack of economic resources and trained personnel. Currently, for every 10 cows that are inseminated, only 2 goats and 3 sheeps are inseminated. This low percentage of inseminated goats has caused that the genetic progress is limited in the caprine species. This technique is focused on the integration of high genetic quality flocks that allow them to use high-value semen and that can be used preliminarily in the programs of embryo transfer and in vitro fertilization [45]. One way of evaluating bucks is through their daughters. The fastest way is to use AI to have daughters in different flocks. To achieve this, it is necessary for producers to use AI to propagate genes from different bucks in their herds. Among the techniques of AI that have been used to increase the rate of conception is the technique of laparoscopy, which consists of the deposition of the semen directly inside the uterine horns, avoiding the natural barrier of the cervix (see **Photo 2**). With this technique, pregnancy rates of 80% with diluted fresh semen and 50–80% with frozen semen are achieved. First, the goat is given a water and food diet for 12 hours to reduce the contents of the bladder and rumen. This facilitates the location of the uterus and prevents regurgitation of ruminal contents. The ability of the inseminator will be the time it takes to deposit the semen in both uterine horns [45]. A highly trained technician can inseminate the goat in 2 minutes. Before initiating endoscopy, the goat is anesthetized locally with 5 ml (20 mg) 2% lidocaine hydrochloride subcutaneously (see **Photo 2**). Take special care to avoid injuring the blood vessels when injecting the anesthesia (see **Photo 3**). Local anesthesia aims to relax the goat and not present ruminant contractions and can visualize the uterine horns. Once the ventral cavity is pierced and in the direction of the nipples of the udder (10 cm of the nipples), the endoscope is inserted (see **Photo 3**). The cavity is inflated with CO_2 to facilitate the localization and manipulation of the uterus. The insemination gun is inserted through the second puncture and inserted into the wall of the uterus into the lumen releasing the semen (see **Photo 3**). Usually, the semen is deposited in both uterine horns to achieve good results of pregnancy. Normally, both uterine horns are inseminated with the Aspic pistol



Photo 2. Observation and manipulation of the uterine horns to carry out the technique of artificial insemination by laparoscopy.

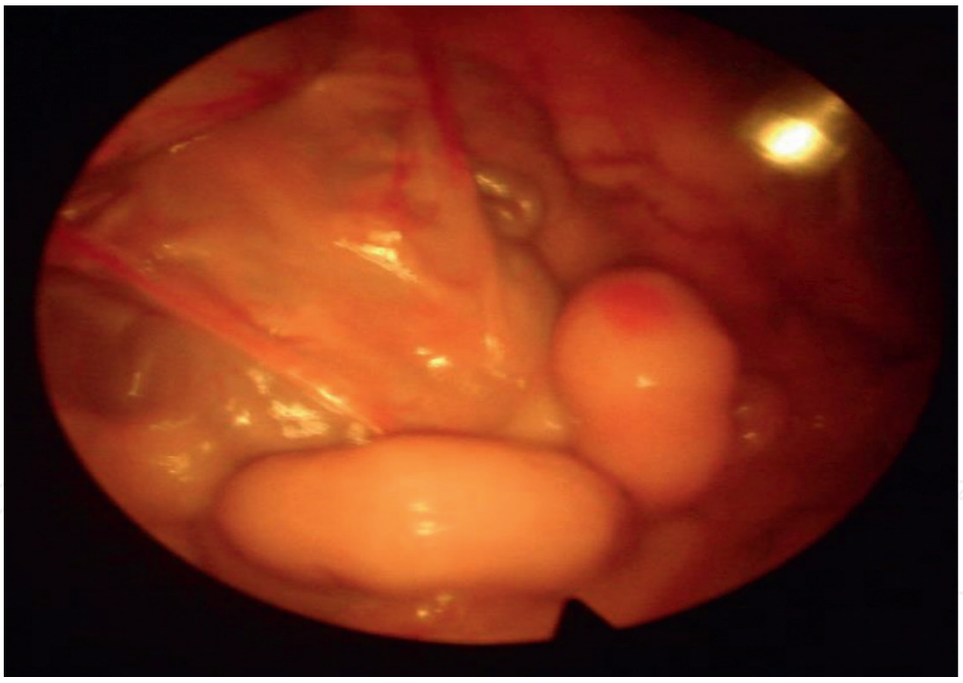


Photo 3. Observation of uterine horns in a goat through laparoscopy with 12 hours of water diet.

(IVM), or the Robertson Pipette from Minitube. The objective is to inseminate in the middle part of both uterine horns, depositing half of the dose in each one of them. The technician must take between 2 and 3 min to inseminate the goat. When fresh semen is used, pregnancy percentages are reached above 80. With frozen semen, percentages are reached between 50 and 80% pregnancy.

Once the artificial insemination is performed, the endoscope is removed, and a commercial disinfectant is placed in the incisions that were made. The amount of sperm deposited per dose varies from 40 to 100 million. The results of this AI technique will depend on other factors, including goats' body condition, insemination time, race, year time, and synchronization protocol, among other factors.

6. Conclusions

Goat production globally has increased in recent years. Therefore, good reproductive strategies are required that are feasible to be applied by producers, such as the synchronization of estrus and ovulation, because it is required to have a more intense selection pressure via bucks (artificial insemination) as goats (embryo transfer and in vitro fertilization).

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References

[1] Delgadillo JA, Duarte G, Flores JA, Vielma J, Hernandez H, Gonzalo FRG, Bedos M, Fernandez GI. Control of the sexual activity of goats without exogenous hormones: Use of photoperiod, male effect and nutrition. Tropical and Subtropical Agroecosystem. 2012;**15**(1):15-27

[2] Delgadillo JA, Martin GB. Alternative methods for control of reproduction in small ruminants: A focus on the needs of grazing industries. Animal Frontiers. 2015;**5**:57-65. DOI: 10.2527/af.2015-0009

[3] Fatet A, Pellicer-Rubio MA, Leboeuf B. Reproductive cycle of goats. Animal Reproduction Science. 2011;**124**(3-4):211-219. DOI: 10.1016/j.anireprosci.2010.08.029

[4] Bukar MM, Malik A, Kurnianto H. Pattern of antral follicular development in goats: A review. International Livestock Research. 2005;**5**:1-13

[5] Arredondo AJG, Gómez AG, Vásquez-Armijo JF, Ledezma-Torres RA, Bernal-Barragan H, Sánchez-Dávila F. Status and implementation of reproductive technologies in goats in emerging countries. African Journal of Biotechnology. 2015;**14**(9):719-727. DOI: 10.5897/AJB2014.14300

[6] Amiridis GS, Cseh S. Assisted reproductive technologies in the reproductive management of small ruminants. Animal Reproduction Science. 2012;**130**(3-4):152-161. DOI: 10.1016/j.anireprosci.2012.01.009

[7] Gama LT, Bressan MC. Biotechnology applications for the sustainable management of goats genetic resources. Small Ruminant Research. 2011;**98**(1-3):133-146. DOI: 10.1016/j.smallrumres.2011.03.031

[8] Jiang YF, Hsu MC, Cheng CH, Tsui KH, Chiu CH. Ultrastructural changes of goats corpus luteum during the estrous cycle. Animal Reproduction Science. 2016;**170**:38-50. DOI: 10.1016/j.anireprosci.2016.04.001

[9] López-Sebastian A, Gonzalez-Bulnes A, Carrizosa JA, Urrutia B, Diaz-Delfa C, Santiago-Moreno J. New estrus synchronization and artificial insemination protocol for goats based on male exposure, progesterone and cloprostenol during the non-breeding season. Theriogenology. 2008;**69**(5):651-657. DOI: 10.1016/j.theriogenology.20017.08003

[10] Lopez Sebastian A, Coloma MA, Toledano A, Santiago Moreno J. Hormone free protocols for the control of reproduction and artificial insemination in goats. Reproduction in Domestic Animals. 2014;**49**(4):22-29. DOI: 10.1111/rda.12394

[11] Mellado M. Técnicas para el manejo reproductivo de las cabras en agostadero. Tropical and Subtropical Agroecosystems. 2008;**9**:47-63

[12] Menchaca A, Rubianes E. Pregnancy rate obtained with short-term protocol for timed artificial insemination in goats. Reproduction in Domestic Animals. 2007;**42**(6):590-593. DOI: 11.1111/j.1439-0531.2006. 00827.x

[13] Paramio MT, Izquierdo D. Assisted reproduction technologies in goats. Small Ruminant Research. 2014;**121**(1):21-26. DOI: 10.1016/j.smallrumres.2014.01.002

[14] Pietroski ACCA, Brandao FZ, Souza JMGD, Fonseca JFD. Short, medium or long-term hormonal treatments for induction of synchronized estrus and ovulation in Saanen goats during the nonbreeding season. Revista Brasileira de Zootecnia. 2013;**42**:168-173

[15] Mellado J, Veliz FG, de Santiago A, Meza-Herrera C, Mellado M. Buck-induced estrus in grazing goats during increasing photoperiod and under cold stress at 25 N. Veterinary Medicine and Zootecnie. 2014;**66**(88):40-45

[16] Knights M, Singh-Knights D. Use of controlled internal drug releasing (CIDR) devices to control reproduction in goats: A review. Animal Science Journal. 2016;**87**(9):1084-1089. DOI: 11.1111/asj.12627

[17] LLanes A, Knox WB, Farin CE. Comparison of controlled internal drug-release insert based and progesterone-free methods for ovulation synchronization and timed artificial insemination of goats. Reproduction, Fertility and Development. 2016;**28**(2):135-139. DOI: 10.1071/RDv28n2Ab11

[18] Fonseca JF, Bruschi JH, Santos ICC, Viana JHM, Maagalhaes, ACM. Induction of estrus in non-lactating dairy goats with different estrous synchrony protocols. Animal Reproduction Science. 2005;**85**(1-2):117-124. DOI: 10.1016/j.anireprosci.2004.03.005

[19] Bowdridge EC, Knox WB, Whisnant CS, Farin CE. NCSynch: A novel, progestagen-free protocol for ovulation synchronization and timed artificial insemination in goats. Small Ruminant Research. 2013;**110**(1):42-45. DOI: 10.1016/j.smallrumres.2012.07.025

[20] Dogan I, Nur Z, Dogan S. Different progestagen treatment duration on estrous synchronization during the natural breeding season in non-lactating Anatolian black goats. Animal Reproduction. 2016;**13**(4):806-810. DOI: 10.21451/1984-3143-AR811

[21] Martinez-Alvarez LE, Hernandez-Ceron J, Gonzalez-Padilla E, Perera-Marin G, Valencia J. Serum LH peak and ovulation following synchronized estrus in goats. Small Ruminant Research. 2007;**69**(1-3):124-128. DOI: 10.1016/j.smallrumres.2005.12.024

[22] Saravia FR, Doradp F, Cox JF. Assessment of an estrous synchronization protocol for fixed-time artificial insemination in dairy goats. Animal Reproduction. 2016;**13**(3):458-458

[23] Talafha Aq, Ababneh MM, Khalifeh MS, Al-Majali AM. Effect of intravaginal fluorogestone acetate sponges on prolactin levels of Damascus-local cross breed goats. Tropical Animal Health and Production. 2015;**47**(2):277-283. DOI: 10.1007/s11250-014-0716-0

[24] Zarazaga LA, Gatica MC, Gallego-Calvo L, Celi I, Guzman JL. The timing of oestrus, the preovulatory LH surge and ovulation in Blanca Andaluza goats synchronized by intravaginal progestagen sponge treatment is modified by season but not by body condition score. Animal Reproduction Science. 2014;**146**(3-4):170-175. DOI: 10.1016/j.anireprosci.2014.01.012

[25] Andrabi SMH, Anwar M, Mehomood A. Efficacy of short-term estrus synchronization protocols and timed artificial insemination in subtropical goats. Journal of Animal Plant Science. 2015;**25**:298-300

[26] Jackson DJ, Fletcher CM, Keisler DH, Whitley. Effect of melengestrol acetate (MGA) treatment or temporary kid removal on reproductive efficiency in meat goats. Small Ruminant Research. 2006;**66**(1-3):253-257. DOI: 10.1016/j.smallrumres.2005.07.052

[27] Navanukraw C, Khanthusaeng V, Kraisoon A, Uriyapongson S. Estrous and ovulatory responses following cervical artificial insemination in Thai-native goats given a new or once-used controlled internal drug release with human chorionic gonadotropin. Tropical Animal Health and Production. 2014;**46**(8):1441-1446. DOI: 10.1007/s11250-014-0662-x

[28] Alvarez L, Gamboa D, Zarco L, Ungerfeld R. Response to the buck effect in goats primed with CIDRs previously used CIDRs or previously used autoclaved CIDRs during the non-breeding season. Livestock Science. 2013;**155**(2-3):459-462. DOI: 10.1016/j.livsci.2013.05.010

[29] Pellicer-Rubio MT, Boissard K, Forgerit Y, Pougnard JL, Bonné JL, Leboeuf B. Evaluation of hormone-free protocols based on the "male effect" for artificial insemination in lactating goats during seasonal anestrus. Theriogenology. 2016;**85**(5):960-969. DOI: 10.1016/j.theriogenology.2015.11.005

[30] Romano JE, Alkar A, Fuentes-Hernandez VO, Amstalden M. Continuous presence of male on estrus onset, estrus duration, and ovulation in estrus-synchronized Boer goats. Theriogenology. 2016;**85**(7):1323-1327. DOI: 10.1016/j.theriogenology.2015.12.018

[31] Nogueira DM, Eshtaeba A, Cavalieri J, Fitzpatrick LA, Gummow B, Blache D, Parker AJ. Short-term supplementation with maize increases ovulation rate in goats when dietary metabolizable energy provides requirements for both maintenance and 1.5 times maintenance. Theriogenology. 2017;**89**:97-105. DOI: 10.1016/j.theriogenology.2016.10.014

[32] Romano JE, Alkar A, Amstalden M. Onset of luteolytic action of exogenous prostaglandin F-2a during estrous cycle in goats. Theriogenology. 2016;**92**:10.1016/j.theriogenology.2016.12.019

[33] Rekik M, Ben OH, Othmane H, Lassoued N, Sakly C. Efficiency of oestrus synchronization by GnRH, prostaglandins and socio-sexual cues in the North African Maure Goats. Reproduction in Domestic Animals. 2014;**49**(3):499-504. DOI: 11.1111/rda.12319

[34] Sumeldan JD, Ocampo LC, Atabay EP, Celestino EF, Lazaro JV, Ocampo MB. Comparison on the efficiency of estrus synchronization methods for artificial insemination in goats. Journal of Agricultural Technology. 2015;**11**(8):2489-2497

[35] Sánchez-Dávila F, Ledezma-Torres RA, Padilla-Rivas G, del Bosque González AS, González Gómez A, Bernal-Barragán H. Effect of three pFSH doses on superovulation and embryo quality in goats during two breeding seasons in north-eastern Mexico. Reproduction in Domestic Animals. 2014;**49**(4):40-43. DOI: 10.1111/rda.12350

[36] Oliveira JDSK, Fonseca JFD, Souza-Fabjan JMG, Esteves LV, Feres LFR, Rodrigues CAF, Brandäo. Protected fatty acid supplementation during estrus synchronization treatment on reproductive parameters of dairy goats. Animal Science Journal. 2016;**88**(2):254-258. DOI: 10.1111/asj.12640

[37] Foote RH. The history of artificial insemination: Selected notes and notables. Journal of Animal Science. 2002;**80**:1-10. DOI: 10.2527/animal/sci2002.80E-Suppl_21a

[38] Dorado J, Rodriguez I, Hidalgo M. Cryopreservation of goat's spermatozoa: Comparison of two freezing extenders based on post-thaw sperm quality and fertility rates after artificial insemination. Theriogenology. 2007;**68**(2):168-177. DOI: 10.1016/j.theriogenology.2007.04.048

[39] Maia MDS. Semen processing and artificial insemination in goats and sheep. Ciencia Veterinaria nos Tropicos. 2015;**18**:65-71

[40] Salvador I, Viudes de Castro MP, Bernacer J, Gómez EA, Silvestre MA. Factors affecting pregnancy rate in artificial insemination with frozen semen during non-breeding season in Murciano-Granadina goats: A field assay. Reproduction in Domestic Animals. 2005;**40**(6). DOI: 10.1111/j.1439-0531.2005.00624x

[41] Yotov S, Atanasov A, Karadaev M, Dimova L, Velislavova D. Pregnancy rate in dry and lactating goats after estrus synchronization with artificial insemination and natural breeding (a field study). Bulgarian Journal of Veterinary Medicine. 2016;**19**(3):218-223. DOI: 10.15547/bjvm.930

[42] Yotov S, Velislavova DV, Dimova LR. Pregnancy rate in Bulgarian White milk goats with natural and synchronized estrus after artificial insemination by frozen semen during breeding season. Asian Pacific Journal of Reproduction. 2016;**5**(2):144-147. DOI: 10.1016/j.apjr.2016.01.011

[43] Daskin A, Tekin K, Tirpan MB, Inanc ME, Cil B, Alemdar H. The effect of different insemination techniques and cervical conformation index on fertility rates in Angora goats. Animal Reproduction Science. 2016;**169**:116abstract. DOI: 10.1016/j.anireprosci.2016.03.053

[44] Arrébola F, Sánchez M, López MD, Rodriguez M, Pardo B, Palacios C, Abecia JA. Effect of weather and management factors on fertility after artificial insemination in Florida goats: A ten-year study. Small Ruminant Research. 2016;**137**:47-52. DOI: 10.1016/j.smallrumres.2016.03.002

[45] Alvarado_Espino AS, Meza-Herrera CA, Carrillo E, González-Álvarez VH, Guillen-Muñoz JM, Ángel-García O, Veliz-Vera FG. Reproductive outcomes of alpine goats primed with progesterone and treated with human chorionic gonadotropin during the anestrus-to-estrus transition season. Animal Reproduction Science. 2016;**167**:133-138. doi: 10.1016/j.anireprosci.2016.02.019

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