Chapter

Reproduction in Small Ruminants (Goats)

Fernando Sánchez Dávila and Gerardo Pérez Muñoz

Abstract

The exploitation of small ruminants (goat and sheep) has always been linked to the development of human civilizations, where they have mainly fed on their derived products such as milk and meat. Currently, the sheep population is around 1 billion head concentrated above 50% in three countries, China, Australia, and New Zealand, contrary to goats with around 720 million heads, distributed mainly in Asia, Africa, and South America. Both species have similar characteristics in some anatomical aspects (a pair of nipples), gestation period (150 days), and presence of seasonal anestrus, differing in terms of magnitude and depth and presence of the male effect. However, they are completely different in feeding habits, nutrient needs, and grazing systems, with differences in terms of the female's reproductive tract, among other characteristics. Currently, the study of reproduction has intensified over the years in the goats and its counterpart that is the buck. Therefore, in the following topics, the importance of global reproduction of the goat will be discussed, considering that progress has been made today in the application of third generation reproductive techniques and that today they are already consolidated and developed in the bovine species.

Keywords: bucks, testosterone, sexual behavior, reproduction in goats, nutrition

1. Introduction

The exploitation of small ruminants (goat and sheep) has always been linked to the development of human civilizations, where they have mainly fed on their derived products such as milk and meat. Currently, the sheep population is around 1 billion head concentrated above 50% in three countries, China, Australia, and New Zealand, contrary to goats with around 720 million heads, distributed mainly in Asia, Africa, and South America. Both species have similar characteristics in some anatomical aspects (a pair of nipples), gestation period (150 days), and presence of seasonal anestrus, differing in terms of magnitude and depth and presence of the male effect. However, they are completely different in feeding habits, nutrient needs, and grazing systems, with differences in terms of the female's reproductive tract, among other characteristics [1]. Currently the study of reproduction has intensified over the years in the goats and its counterpart that is the buck. Therefore, in the following topics, the importance of global reproduction of the goat will be discussed, considering that progress has been made today in the application of third generation reproductive techniques and that today they are already consolidated and developed in the bovine species [2].

2. Reproduction in goats

In most areas of the world, goats are mated once yearly in the fall, during their natural mating season, for spring kidding [3–5]. Animals bred at this time are more likely to get pregnant and have multiple kids. A longer breeding season allows for flexibility in breeding and kidding dates to times when the climate is more favorable, and forage is available for the lactating doe. In addition, dates of ethnic/alternative markets should also be considered in the decision about when to breed females. How long the males are kept in with females for mating determines how long kidding will last, but a 40 to 45-day breeding season will guarantee that each doe has had at least two opportunities to come into heat. The male-to-female ratio in this breeding system is approximately 1 male per 30–40 females, but in synchronized breeding, this ratio should be 1 male with 20 or less females.

Likewise, under range conditions, bucks are often maintained with the doe herd throughout the year for continuous breeding. In such a system, proper health management is difficult and only limited supervision can be provided during kidding [1]. Care is also required to routinely remove offspring from the herd to avoid mother/son and father/daughter mating's. Although buck exposure is continuous, kidding under continuous mating will eventually follow seasonal breeding patterns, depending on the location of the farm and the breed of goat used.

However, globally, in intensive milk production systems, the use of basic reproductive techniques has been applied more extensively, for example the estrus synchronization techniques, artificial insemination, (AI), is being used more commonly by goat producers [6]. Artificial insemination makes it possible to obtain or transfer genetic material domestically and internationally. Many goat producers, both meat and dairy, utilize AI to produce animals that are more desired by markets and consumers as well as animals that will do well at local, state and national livestock shows.

2.1 Perspectives and advances in the study of the estrous cycle of the goat

Currently the estrous cycle is being studied from a perspective of hormonal changes according to the ovarian structures that are present during each of the phases that occur (follicular and luteal) [7, 8]. The above is with the objective of evaluating the size of structures and correlating them with hormonal profiles. Considering that by understanding the physiology and anatomy and the perspective of manipulating the oestrus cycle, we can advance or achieve higher gestation rates [9]. It has been stabilized with the application of hormonal products and/or the male effect to have an oestrus presence of 100%. However, pregnancy percentages vary greatly according to a large number of factors (see **Figure 1**), where each of them affects the final result cross-sectionally, which is pregnancy.

Estrous induction began to develop in goats and sheep for more than 50 years, where injected progesterone began to be used daily, until today with the use of two types of vaginal devices: vaginal sponge and delivery device. Controlled (CIDR), each having its advantages and disadvantages [10, 11]. The response in each of the devices has been accompanied by secondary hormones of intramuscular application that favor the development of the follicles, the synchronization of them for their ovulation and that these become corpus luteum with adequate size and with a sustainable production of progesterone. It is well known that low LH levels during the progestogen synchronization protocol will affect the fate of large follicles. However, these follicles require LH for their maintenance and development, so they

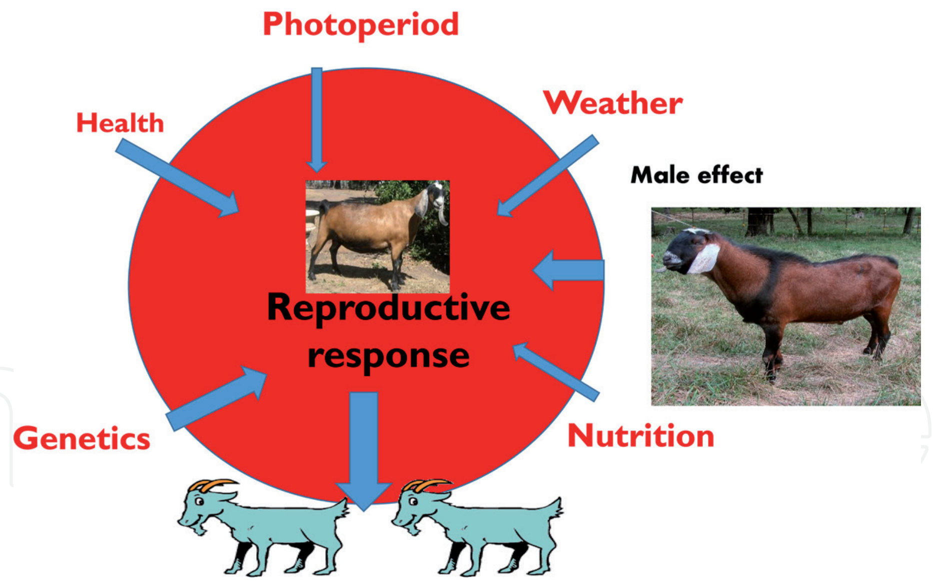

Figure 1.
Factors that affect the reproductive response in goats.

will present atresia and new ovulatory follicles appear that will grow. In long estrous synchronization protocols (above 10 days), when the vaginal devices are removed, they release little progestogen and do not completely suppress LH. With the above, an abnormal follicular development occurs, which become persistent, leading to low fertility and therefore gestation.

2.2 Will it be possible to improve the parameters of presence of estrus and pregnancy using hormones in the coming years?

Changes or results in estrous synchronization programs have been modified over the years depending on the duration of insertion of the sponge or the device in the goat, however, the use of hormones to regulate goat reproduction has been maintained over the years [12, 13], with changes especially in the higher use of nonsteroidal hormones, such as those derived from prostaglandins, gonadotropin-releasing hormones, and hormones of follicular growth and development such as equine chorionic gonadotropin; being the most frequent use in the European community for health reasons. The use of steroid hormones such as progestogens continue to be used globally [14], but under the premise of using short protocols (5 to 7 days). In the present and in future years the use of short protocols of 5–7 days will be used more and more because it has a series of advantages compared to short protocols; these being the decrease in the presence of vaginitis in animals; in the case of CIDR devices, reuse them up to twice more with an effectiveness of up to 90% of estrous in goats. However, the health risk must be considered as it can contaminate bacteria, viruses from one animal to another.

The important thing is to be able to develop vaginal devices with a lower concentration of progesterone and avoid being reused to avoid this type of infection.

On the other hand, the use of estrous synchronization protocols in goats using nonsteroidal hormones in combination with the male effect has been developing more intensively in recent years. For example, the administration of double doses of PGF2α is recommended to synchronize estrous in cycling goats, with an interval of 10–14 days (appointment), which ensures that most does will present the mid luteal phase, when applying the second dose, and that all will respond with the behavior of estrus and ovulation (appointment). However, their response may vary depending on the insemination technique, the dose to be applied and the interval between doses. Besides, it should be considered that only the goat that is cycling with the presence of an active luteal body, would work this protocol. Currently, the male effect is used, so that an estrus occurs, a CL is formed, and the protocol based on prostaglandins is started.

In goats, PGF2α and its analogs are effective luteolytic agents, where very small doses (1.25 mg) of PGF2α are currently required, with the corpus luteum being more sensitive compared to cows. Likewise, responses to low doses of its analogues, such as cloprostenol, have been observed; 125 μg doses have been used in goats, but even a 26 μg dose has been shown to be effective [15, 16]. As in sheep, the age of the corpus luteum and, therefore, the day of the cycle in which PGF2α is administered determines the degree of synchronization obtained and the time required for the heat to appear, the LH peak and the ovulation [17]. Several studies indicate that goats treated on day 6 of the cycle go into heat and show an LH peak much earlier than those treated on day 12 [18, 19].

2.3 Advances and use of the male effect, a case study until today!

The use of the male effect (**Figure 2**) has been a case study up to nowadays at a global level [20, 21], where different alternatives have been evaluated in order to understand its way of acting under different scenarios of a goat production system and achieve further efficiency in reproduction in the goat [22]. The sudden introduction of the goat increases the release of LH in goats [23], where the first estrus is not silent [24], so the goat effect produces a high degree of estrus synchronization [25]. Also, short cycles of 5–6 days or 10–12 days may appear after introducing the male, in these cases fertility is lower than in normal cycles [26]. Over the years, different scenarios of the male effect have been validated, modified or compared [27]; for example, [28] determined that the male-female ratio does not decrease the ability of sexually active males to induce sexual activity in anovulatory goats, but it does delay the response to the male effect. Likewise, [29] determined that the separation of the goats from the male goats is not necessary as it was thought in previous years to be able to stimulate the sexual activity of goats subjected to the male effect. Followed by another investigation where they verified that the bleating

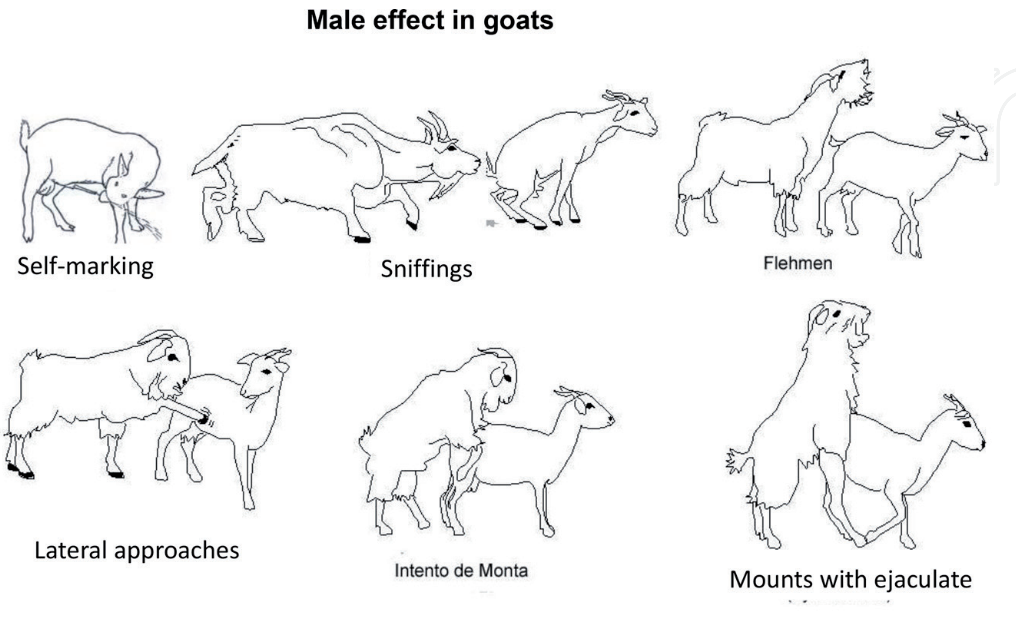

Figure 2.
Sequence of sexual behavior in bucks.

(vocalizations) of the goat were not sufficient to stimulate the presence of estrus and ovulation, therefore, the frequency of pulses of the LH was not increased [30]. Likewise, there are studies where the introduction of estrogenized females when introducing the buck can stimulate the estrous activity of anovulatory goats [31]. Delgadillo et al. [32] reviewing the male effect on goats, mention that in previous years it was mentioned that the male should be in permanent contact with the goats, their studies elucidated that it is not necessary and with a minimum contact of 4–16 hours, percentages of estrus can be reached in goats subjected to the male effect, the same as in groups that are in permanent contact with the males.

However, despite the advantages of using the male effect in goats, even today in large goat populations its use has been limited to continue with the natural breeds according to the time of year. Perhaps the lack of basic infrastructure to install and separate the bucks who are going to have the light programs have made their practical application until today still limited.

2.4 Male social hierarchy and its impact on reproduction

One of the key aspects to improve the performance of the herd is the proper evaluation of the reproductive capacity of the male, performing both a general physical examination, a specific examination of the reproductive system, a seminal quality examination and another of their libido and ability to mount. [33], with the aim of ensuring an adequate selection of males that contribute to improving the efficiency and profitability of the reproductive unit (**Figure 3**).

Previous studies have evaluated the social hierarchy in rams raised in pairs, identifying that the dominant males exhibit a greater sexual precocity and a greater reproductive capacity compared to the subordinate males. A negative influence on testosterone production has also been reported, due to the stress of the grouping of bucks [34–36].

In goats housed in herds with different densities, the social interactions registered between them were evaluated, as well as the levels of cortisol in blood to determine if the levels of said hormone vary depending on the size of the herd,

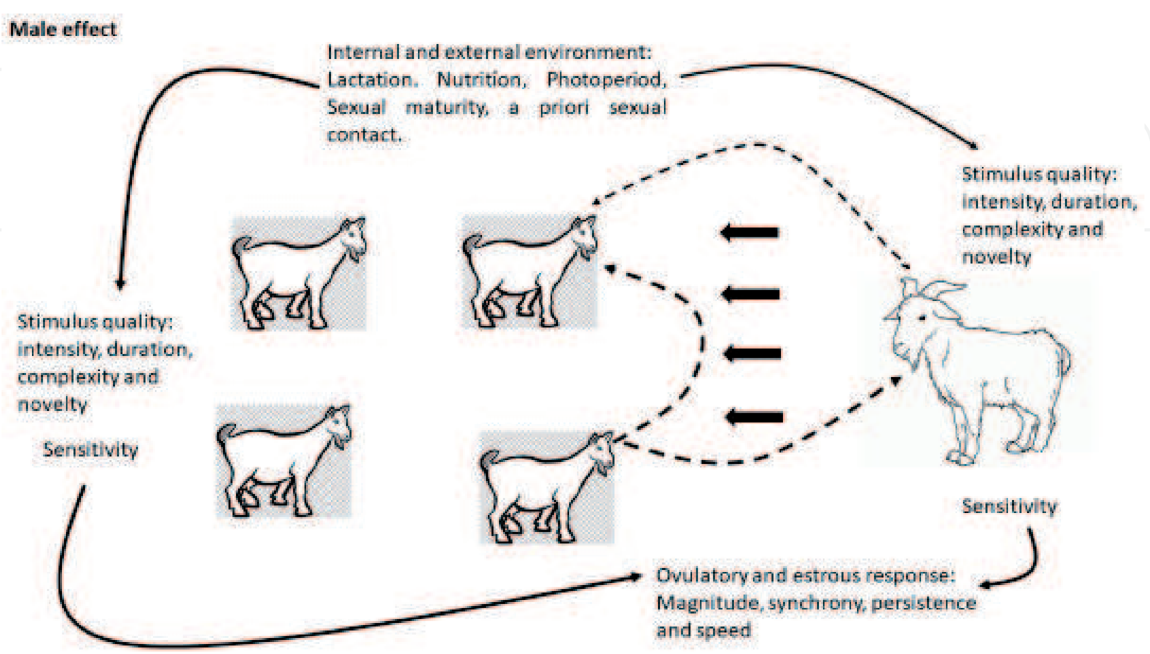

Figure 3.
Factors influencing the presentation of the male effect in goats.

identifying that the size of the pen and the size of the herd influences the increase in stress due to clustering, negatively impacting the weight gain of the bucks and the productivity of the herd [37, 38].

Ivasere et al. [39] recorded behavioral changes by intensifying production systems and their effect on productive aspects such as nutrition, reproduction and diseases. They observed that the social structure is of great importance in the physiological and ethological development in bucks, modifying the frequency of courtship, copulation and the stress level in bucks grouped in herds of different densities. So far there is little information in the literature about the effect of regrouping previously raised male goats in pairs and regarding how serum cortisol and testosterone concentrations, seminal quality and sexual behavior are affected after such grouping.

2.4.1 Cortisol and stress physiology in bucks

Within the management of goats, efforts have been made to develop strategies to improve the quality and efficiency within the herds. At an intensive level, the management carried out ranges from supplying drugs, palpation, semen extraction, and pen cleaning. These management activities, in conjunction with other factors, such as the size of the herd, overcrowding, feeding or the immune system of animals, influence the body's physiological response to various stressful situations [40]. The most common stressors in goat production are mainly those caused by environmental heat and the increase in body temperature, deprivation or lack of access to food or water, as well as modifications in the hierarchical structure of the herd or change of habitat [41].

Among the responses at the physiological level present in male goats in stressful situations is the secretion of glucocorticoids (GC), which exert a negative feedback effect on the hypothalamic-pituitary-gonadal axis, reducing the synthesis of GnRH and together thereby inhibiting the synthesis of gonadotropins and sex steroid hormones [34, 39]. This endocrine mechanism aims to stimulate the body to respond to stressors, such as loss of appetite, suppression of the immune system, energy mobilization, vasoconstriction, and loss of erection and receptive sexual behaviors [42].

2.4.2 Social factors and sexual behavior in males

The grouping of bucks is a widespread practice mainly in stable and mixed management systems around the country [17, 43].

The study of behavior has shown that the establishment of hierarchical ranks and social organization influence sexual behavior that will be exhibited by a male under grouping conditions [44]. This dominance is related in turn to the live weight of the animal and its age, mainly as part of a display of reproductive competition, which guides producers as a key criterion for selecting males [45, 46].

By remaining in coexistence conditions, one of the males tends to monopolize access to the females in estrus in order to ensure their reproductive success, being this considered the dominant male [47], which initiates a display of dominance behaviors, such as competition due to access to food, increased physical activity and hoarding of better resting places, while the subordinate male at the hierarchical level initiates evasive or submissive behaviors and sexual behavior is characterized by opportunistic-type strategies [48]. The dominant male is characterized by having a more aggressive behavior compared to the rest of the males and is also the one with the highest sexual activity [49].

Among the activities carried out mainly by the dominant male, the increase in vocalizations, head movements, tapping, lunges and displacement and protection of the female in heat (tending) from other males stands out [42], thus reaching inhibit the sexual behavior of subordinate males [36].

According to Mainguy et al. [41], the establishment of the dominance position is accentuated with the secondary sexual characteristics, which is also related to the age and body weight of the animal [50], helping to strengthen the male's hierarchical position and social structure within the herd. As they reach sexual maturity, the frequency of mounting with ejaculate, the performance of riding and the production of semen in dominant bucks compared to subordinate's increases [36].

2.4.3 Measurement of sexual behavior in bucks

To determine the potential as a possible male, it is necessary to establish tests that allow the identification and categorization of males according to their score, taking into account comprehensively both their physical characteristics, such as weight, body condition, and sexual behavior [1].

Assessments to determine mount efficiency in bucks typically consist of exposing a male to a female in estrus, for a period of time ranging from 15 to 20 minutes to 1 hour in a pen without distractors [51]. During this period, an observer keeps track of the amount of sexual behavior. They are rapid, practical and inexpensive tests that allow identifying the willingness of the male to serve the female and together with this, discard males with unsuitable profiles within a reproductive program in natural mating in the shortest possible time [52].

In tests of reproductive capacity, motivation is linked to the animal's libido and for this reason some authors recommend the use of more than one female in estrus [49]. Other factors that influence the performance of males in the evaluation of reproductive capacity are the breed of the animal, season of the year, age, the sexual experience they have and the hierarchical position that the male occupies [33].

For the evaluation of sexual behavior in bucks there are different strategies that can be implemented to determine acts of courtship and mating acts. The reaction time test allows us to identify the time it takes for the male to achieve the first mount with ejaculate and thus have an estimate of the libido of the evaluated male [11].

The service ability test is one of the most widely used tests. It consists of placing the male before one or several females in heat for a certain period, usually between 15 to 60 minutes in a pen. During this period an observer counts the number of interactions between the male and the female (s), which can be optionally rated or, only indicate the frequency with which the courtship acts, the mounts or the ejaculations occur as the case may be [42].

Observations can be made individually or in groups. Individual observations should be made in the absence of other males, while group observations should take into account that they must be of similar ages to give accuracy to the test, seeking to carry out at least three tests to estimate service capacity [25, 53, 54].

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