

# Reproductive Management of the Male Goat: A Review

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## ABSTRACT

**Objective:** To describe the factors affecting male goat (buck) reproduction and the selection and management strategies to improve their reproductive efficiency.

**Design/Methodology/Approach:** By reviewing published information, the main factors that affect the reproductive capacity of bucks and some management strategies for their reduction were described. Emphasis was on the evaluation of seminal quality, libido, and the selection of sires to be used in the herd.

**Results:** Proper sire diet reduces age at puberty and improves testicular and seminal characteristics, as well as sexual behavior. The effect of seasonality can be improved by using melatonin implants and adequate nutrition.

**Study Limitations/Implications:** In goat production systems, bucks are important for the production of quality livestock and the products and byproducts from this species. Understanding the impact of environmental factors such as nutrition, seasonality, and physiological processes on the reproductive capacity of bucks promotes the establishment of management strategies to better understand what is important when selecting sires as sperm donors to improve product quality and to obtain greater herd production.

**Findings/Conclusions:** Adequate sire nutrition improves herd fertility. Seasonal reproduction affects the reproductive capacity of sires as sperm donors, yet there are management alternatives to reduce such seasonal effects on their reproductive performance.

**Keywords:** reproductive strategy, nutrition, libido, reproduction.



## **INTRODUCTION**

Goat production represents a viable income alternative in places where there is a shortage of feed for other animal species and provides producers in these areas with a production alternative, especially in the form of kids (Escareño *et al.*, 2011). In turn, there is a strong influence of environmental factors on production, where the reproductive season, fluctuations in feeding and environmental conditions determine the reproductive capacity of herds (Dubeuf, 2011). In these production systems, the buck plays an important role in obtaining good productive and reproductive efficiency (Ridler *et al.*, 2012).

Reproductive management of the male is the set of systems, practices and manipulations aimed at improving the efficiency of goat male reproductive performance (Luo *et al.*, 2019), since there are several factors throughout the year that affect semen production; among these, some are related to nutrition, with changes in day length (photoperiod), or to the ratio of number of females per male, among others. Variations in nutritional conditions increase or decrease testicular size, which is highly related to daily sperm production (Smith *et al.*, 2018). This is further accentuated by the extensive management of the animals, so that bucks subsist throughout the year exclusively on native vegetation, which affects semen quality due to the fluctuation of nutrients and photochemicals in forage (Delgadillo *et al.*, 2021).

In goats, reproductive activity is seasonal, as it is influenced by the photoperiod (daylight hours), which determines annual variations in libido, seminal quality and testicular size in goats. Testicular size is related to sperm production, and can be estimated by scrotal circumference (SC; Maroto-Morales *et al.*, 2016). Stimulation with light or melatonin implants induce an increase in plasma testosterone concentrations during seasonal anestrus (long days), which induces reproductive activity in male goats (Zarazaga *et al.*, 2010). The proportion of females that the male will mount during the mating season and the number of females per male are related to the age and nutritional status of the sire, the time of year, terrain and feed availability (Ridler *et al.*, 2012). Therefore, the objective of this literature review is to describe buck selection and management strategies to improve the reproductive and productive efficiency of the goat herd.

## **AGE AT PUBERTY**

Puberty is the condition in which animals begin the reproductive period. The maturity of the reproductive apparatus and the onset of sexual activity are dependent on body development, therefore, good nutrition is essential. Other important factors affecting age at puberty are breed and time of birth (Sarma *et al.*, 2019). Under normal conditions, males reach puberty at between 4 and 6 months of age and with 60% of their adult weight. Once males have reached puberty, they can be used for breeding, although in seasonal breeds it is common to wait until the following breeding season, when they are between 17 and 19 months of age (Ridler *et al.*, 2012).

## **SIRE SELECTION, SEMINAL QUALITY AND LIBIDO**

It is important to understand the factors that affect the reproductive activity of sires, since the reproductive efficiency of the herd depends to a great extent on them. Higher

ranking males have more opportunity to mate, although it is important to make sure that the sire is competent in its reproductive functions (Wang *et al.*, 2015); therefore, prior to mounting, it is advisable to check the body condition of the male, since sperm production can be reduced, either by excessive feeding (fattening) or by poor feeding during a prolonged period with a notable increase or decrease in weight (Delgadillo *et al.*, 2021). High environmental temperatures also affect fertility and reproductive behavior by altering semen quality, decreasing ejaculate volume, sperm concentration, motility and the percentage of live sperm. Although bucks can cover and reproduce year-round, their sperm quality and mating ability is lower in spring and summer, relative to the normal breeding season which is in the fall (Miah *et al.*, 2016).

### ASSESSMENT OF SEMEN QUALITY AND LIBIDO MANIFESTATION

**Semen evaluation.** Goat semen is evaluated by determining a series of macro and microscopic characteristics to classify the semen sample as viable or not for use. Ejaculate volume. It is measured directly in the calibrated collecting tube and this characteristic varies with the season of the year, the body condition of the males, and it decreases as the frequency of semen collections within a day or within a short period increases. Ejaculate volume varies throughout the year, being lower in January and February (0.44 mL) compared to the other months of the year (0.86 mL; Chentouf *et al.*, 2009).

**Sperm concentration.** It is the amount of sperm cells per milliliter of semen, and ranges from 0.9 to  $2.8 \times 10^9$  sperms per milliliter in Saanen males (Turk *et al.*, 2011).

**Semen mass motility.** It is a subjective estimation test and is extremely sensitive to environmental conditions such as cold or heat. On a slide, previously warmed to a temperature of 37 °C, a drop of semen is placed and observed under an optical microscope, the swirls formed by the movement of the spermatozoa are classified on a scale of 1 to 5 as mentioned in the technique described by Ax *et al.* (2000), recording the value for each sire (Table 1).

**Sperm morphology.** This test determines the amount of abnormalities in the spermatozoa, and consists of smearing with a supra-vital stain based on a mixture of dyes; eosin and water-soluble nigrosine are mixed in a ratio of 1 part semen to 6 parts dye and fixed on a slide with heat (Bamba, 1988). Once the smear is done, 100 sperm cells are counted under the microscope with a 100X objective and the number of cells with alterations is determined; the number of abnormalities present in each ejaculate is recorded.

**Table 1.** Classification of mass mobility by vigor in semen eddies (adapted from Ax *et al.*, 2000).

Classification	Movement categories
0	Total immobility
1	Individual mobility
2	Very slow mobility
3	Slow mobility, with amplitude in the ripples
4	Rapidly moving ripples, waves absent
5	Rapidly moving ripples, waves present

**Live spermatozoa.** The amount of live cells is determined by staining with eosin nigrosine, already mentioned for abnormalities; for this case, the same smear made for the previous test is used, 100 cells are counted under the microscope using the 40X objective and those spermatozoa that remain uncolored are considered alive, while those colored are considered dead (Duran, 1980).

**Sire evaluation.** To evaluate the mating ability of the stallion, there are several tests in which the male is introduced in open or closed pens, where its mating ability is evaluated in periods of different duration (Ridler *et al.*, 2012). Orihuela (2014) proposes the following tests to evaluate the sires' libido:

1. Reaction time to first mounting. In a pen with females, one in estrus is introduced; the test consists in recording the time it takes the buck from the time he enters the evaluation pen to locate the female in heat and until the first ejaculation is achieved. This measure is a good estimator of the buck's libido.
2. Satiety test. Considers the maximum number of services in a given female.
3. Reproductive efficiency test. It is an evaluation of great practical value for producers and can be calculated from three points of view: a) The total number of females impregnated by a male during a restricted period of mating. b) The proportion of females in heat, copulated at least once by the male. c) The number of mountings per ejaculate observed in the same male during a given period. The "serviceability test" consists in exposing the sexually mature male to one or several adult females for a determined time (between 15, 30 and up to 60 min) under pen conditions. In some cases, the number of ejaculations achieved during this period is counted, while in others, its sexual behavior is graded by awarding points to courtship activities, mounting, and ejaculations. The first will be worth 1 to 5 points, depending on intensity and complexity, mounting will be worth 5 points, and ejaculations will be worth 10. At the end, the accumulated points are added up and higher scores will reflect the best breeders, while males with 0 points are sexually inactive (Orihuela, 2014).

**Testicular measurements.** It is important to determine the measurements related to the external genitalia, especially the testicles, since there is a relationship between body development and testicular size, and it is indicative of sperm production. Scrotal circumference has been widely used to evaluate the reproductive capacity of males, since there is a correlation between scrotal circumference and testicular weight (0.92), number of spermatozoa in the testes (0.77), and number of spermatozoa in the epididymis (0.82); therefore, an increase in scrotal circumference is associated with an increase in ejaculate volume and semen motility (Ridler *et al.*, 2012).

Scrotal circumference measurement is simple, fast and accurate; it is performed with a flexible tape measure placed on the widest part of the testicles. Scrotal circumference is a good indicator of puberty in young goats, and of semen quantity and quality in adult goats. Regardless of breed, puberty in bucks is reached when scrotal circumference reaches 24 cm; while, in adult bucks, regardless of breed, scrotal circumference should be at least 24 cm (Mellado, 2008). When measuring testicular size, it is important to also assess testicular

tone, understood as the consistency of the testicular tissue, since there are some congenital or infectious pathologies that increase the size of one or both testicles, situation that can cause alterations in the production and quality of semen or degeneration of the testicular tissue (Ridler *et al.*, 2012). However, scrotal circumference shows important variations between breeds and is affected by the season of the year (Ridler *et al.*, 2012). The classification of bucks based on scrotal circumference described by Mellado (2008) is shown in Table 2.

### THE BUCK'S DIET

**Influence of the diet.** Nutrition is a factor that influences the reproductive performance of sires, because changes in body weight cause variations in testicular size, which directly affects the daily semen production per gram of testicular tissue. Therefore, it is important to balance diets taking into account levels of protein and energy. The nutritional level of the males has a great influence on the age at puberty, so when the diet is balanced and correct, the sires mature in a shorter time, with a higher number of spermatozoa and better ejaculate quality when the male is used to service for the first time (Mapletoft *et al.*, 1998).

**Feeding strategies.** In sires, providing a feed supplement eight weeks prior to mating improves sexual behavior, libido and spermatogenesis, because the sperm production process lasts about 56 days. Thus, males supplemented to meet their nutritional needs had better scrotal circumference, ejaculate volume and sperm concentration 63 days after the start of treatment, compared to males fed a base diet (Guan *et al.*, 2014). Parenteral application of sodium selenite prior to mounting in Saanen males increases testicular volume, sperm concentration, semen motility, and decreases sperm abnormalities (Lukusa and Lehloeny, 2017).

### SEASONALITY AND MANAGEMENT STRATEGIES TO REDUCE IT

There are species where reproductive activity is restricted to one season of the year, known as reproductive seasonality, the objective of which is to allow offspring to be born at the most favorable time of the year to ensure their survival. In the male, reproductive seasonality regulates testicular size, testosterone production and semen, and modifies sexual behavior (Gerlach and Aurich, 2000). Chentouf *et al.* (2009) report seasonal effects on testicular measurements, seminal characteristics and testosterone concentrations of sires (Table 3), which confer different mating abilities throughout the year. This is important because testosterone concentrations are related to male aggressiveness, which varies with the seasons and female stimulation (Ungerfeld *et al.*, 2016).

Bucks with a high nutritional plane (1.6 times the maintenance requirement) had better copulation and ejaculation behavior with females than bucks on maintenance diet (Zarazaga *et al.*, 2009). Although seminal characteristics did not change during anestrus

**Table 2.** Criteria for classifying adult male goats (adapted from Mellado, 2008).

Characteristic	Satisfactory	Questionable	Not Satisfactory
Scrotal Circumference (cm)	24 - 27	20 - 23	>20
Testicular tone	firm	hard or soft	very hard or soft

**Table 3.** Seasonal variation of sperm parameters and gonadal measurements in local male goats from northern Morocco (adapted from Chentouf *et al.*, 2009).

	Autumn	Winter	Spring	Summer	P
Scrotal circumference (cm)	24.0c	24.3c	26.3b	27.7a	0.001
Testicular diameter (cm)	5.0b	4.6c	5.3b	5.6a	0.001
Testicular length (cm)	8.8a	7.7b	8.1b	9.0a	0.001
Volume (mL)	0.85a	0.44b	0.82a	0.92 a	0.001
Concentration ( $10^9$ mL <sup>-1</sup> )	2.79b	1.89c	3.61a	3.43ab	0.001
Plasma testosterone (ng mL <sup>-1</sup> )	9.2a	2.0b	3.8b	14.22a	0.001

due to the effect of nutrition, the improvement in mounting behavior is important to stimulate the reactivation of females in their reproductive activity.

Another way to activate the buck is through implants containing 18 mg of melatonin, since this increases testosterone levels and improves seminal characteristics (Zarzaga *et al.*, 2010).

## CONCLUSIONS

It is important to evaluate bucks prior to mating to verify their reproductive capacity through assessment of libido and seminal characteristics that allow gestation of the assigned females. Providing the male with a feed supplement 63 days before mating improves scrotal circumference, ejaculate volume and sperm concentration, which allows for greater fertility in the herd. The time of the year affects the reproductive activity of the sire; however, there are management alternatives to reduce it.

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