Some factors affecting the reproductive capacity of hair rams in the American Tropics

Gómez-Vargas, Julio C.[1]; González-Maldonado, Juan[2]; Torres-Hernández, Glafiro[3]; Cuicas-Huerta, Rosendo[1]; Conde-Hinojosa, Miguel P.[4]; García-Salas, Alejandro[5]; Sarabia-Salgado Lucero[1]; Muñoz-García, Canuto[1*]

[1] Facultad de Medicina Veterinaria y Zootecnia, Universidad Autónoma de Guerrero, Ciudad Altamirano, Pungarabato, Guerrero, México, C. P. 40610.
[2] Instituto de Ciencias Agrícolas, Universidad Autónoma de Baja California, Ejido Nuevo León, Valle de Mexicali, Baja California, México, C. P. 21705.
[3] Colegio de Postgraduados Campus Montecillo, Montecillo, Texcoco, Estado de México, México, C. P. 56264.
[4] Instituto de Ciencias Agropecuarias de la Universidad Autónoma del Estado de Hidalgo, Tulancingo, Hidalgo, México. C. P. 43600.
[5] Departamento de Producción Animal, Universidad Autónoma Agraria Antonio Narro, Saltillo, Coahuila, México. C. P. 25315.
* Autor para correspondencia: cmunoz@uagro.mx

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ABSTRACT

Objective: to analyze within scientific databases some factors that affect the reproductive capacity of hair rams in the American Tropics.

Design/Methodology/Approach: Scientific databases as Web of Science, PubmEd, Scopus, Redalyc, Scholar Google, Dialnet, SciELO and Latindex containing scientific information were reviewed and analyzed to describe nutrition, libido and semen characteristics in hair rams.

Results: nutrition has been reported to affect sperm production, libido, testosterone, and testicular development. Rams start puberty at varying age, therefore with different weight, scrotal circumference, and semen characteristics. In regard to breed, scrotal circumference and semen characteristics are very diverse. Regarding age, semen quality is lower in young rams than in adults. According to the season, there were better semen characteristics in dry seasons in Mexico and in Brazil in the humid season.

Study limitations/Implications: information on nutrition, libido, semen characteristics, and scrotal circumference of hair ram breeds is poorly known or non-existent.

Findings/ Conclusions: the onset of puberty in hair rams is highly variable. The Blackbelly and Santa Inés rams had the best semen characteristics. Young rams have inferior semen quality. In Mexico, rams have better semen characteristics in the dry season, while in Brazil this occurs in the humid season.

Keywords: nutrition, libido, puberty, breed, age.

INTRODUCTION

The reproductive efficiency of sheep herds depends, among other things, on the reproductive capacity of rams. So it is of utmost importance that rams are kept in optimal physical and reproductive conditions to improve profitability in the production unit

(Edwards *et al.*, 2015). Rams have very specific characteristics in their sexual behavior. In general, they are seasonal breeders that show along the photoperiod a higher reproductive capacity in the months with shorter days; and lower reproductive capacity during the months with longer days. In the tropical region, this reproductive capacity is related to the availability of food and to some climate conditions (Scaramuzzi *et al.*, 2006). It is reported that the best time for the lamb to start its reproductive life is at one year-old. During this period, both semen quality and libido expression are better (Morón-Cedillo *et al.*, 2012). At this time, the ram has reached adequate growth and development to begin its reproductive activity.

If the reproductive capacity of an ewe is diminished, it affects the reproduction of only that female during an estrous cycle. On the other hand, if the reproductive capacity of a ram is affected, this compromises the reproductive response of all the ewes in the flock that depend on that ram (Cárdenas-Gallegos *et al.*, 2012; Aké-López *et al.*, 2016). An effective way to know if a ram is suitable for breeding is testing it for reproductive capacity and sexual behavior. The reproductive capacity of rams can be evaluated directly with the physical examination of testicles, penis, and observation of libido. Indirectly, it is evaluated by observation of semen characteristics of rams (Aké-López *et al.*, 2017). At present, the reproductive characteristics of some breeds of hair sheep in the American tropics are generally unknown. Due to the above, the objective of this review was to analyze scientific databases to describe some factors that affect the reproductive capacity of hair rams in the American Tropics.

Factors Affecting the Reproductive Capacity of Hair Rams

The reproductive capacity of a ram can change throughout the year and be influenced by multiple factors, including nutrition, libido, puberty, breed, age and season (Sánchez-Dávila *et al.*, 2011; Aké-López *et al.*, 2017). It is important to mention that the information summarized here on nutrition and libido is the result of research generated in wool rams. Something similar can be assumed in hair rams.

Nutrition

It is now well known that nutrition affects sexual activity, testicular development, sperm quantity and quality in most rams (Joshi, 2022). It has been reported that some variation in feed intake appears to have little effect on testicular endocrine function. However, there is evidence that sperm production is affected by changes in the size of the seminiferous tubules, which affects sperm characteristics in sexually mature rams (Martin *et al.*, 2010). In the case of long-term underfeeding, there are changes in the endocrine function of the testicles which is reflected in a decrease in testosterone synthesis (Martin *et al.*, 2010). It has also been established that the onset of puberty depends on age, body weight and percentage of fat accumulated in animals, which in turn depend on nutrition to activate the neuroendocrine system and with it, the reproductive activity (Plant, 2015; Lea and England, 2018).

The specific importance of energy and protein in sheep feed is vital, because a deficit of these nutrients affects the reproductive functions of prepubertal animals and generates

irreversible damage at the neural and gonad level, unlike adult males (Joshi, 2022). Pang *et al.* (2018) evaluated the effects of energy restriction and compensation on testicular development in sheep. Those authors showed that this restriction induced a decrease in testicular weight and number of sperm cells in the seminiferous tubules. It also caused autophagy and cellular apoptosis in the testicles. However, once the lambs were provided with an energy-balanced diet, there was a compensation of the variables evaluated. On the other hand, Guan *et al.* (2014) showed that sexually active rams, underfed for 65 days, showed reduction in testicular mass and sperm production. This affected sperm quality, as evidenced by a reduction in sperm velocity and DNA damage.

Libido

In the male sheep, libido is referred to reproductive drive and behavior. It is a fundamental characteristic to have good reproductive indicators, since it defines the availability of rams to mate and participate in reproductive activities (Orihuela-Trujillo, 2014). The sexual impulse to mate is influenced by certain factors, among which body condition, time of year, hormones, general health, social interactions and stress are highlighted (Maksimović *et al.*, 2021). Testosterone has among its main functions the regulation of libido; there must be a balanced hormone level for males to have normal sexual behavior (Chacón *et al.*, 2019). Some studies have shown that intramuscular administration of glutamate or glutamate combined with testosterone in Dorper rams improved sexual behavior, with good libido they better displayed their ability to detect and mate with ewes in estrus. This increased the chances of conception and there was also a better reproductive response in the ewes (Calderón-Leyva *et al.*, 2017).

The overall health of the animal is important; for a ram with impaired health, certain diseases and nutritional deficiencies can affect libido (Cruz-Espinoza *et al.*, 2021). Nutritional deficiencies can affect the production of sex hormones. It is recently known that some animals may have a genetic disposition to a stronger or weaker libido (Juengel *et al.*, 2019). In some sheep breeds, libido has a seasonal behavior due to the length of the day and climate conditions; also, it can vary throughout animal reproductive cycle (Alhamada *et al.*, 2017). Environmental conditions such as temperature and irradiation have an impact on libido. Likewise, environmental stress can reduce it, while a comfortable environment can favor it (Maquivar *et al.*, 2021).

It has been reported that other mating experiences and previous interactions with females can influence libido. Negative experiences can decrease the disposition for mating, as well as the presence and behavior of other animals, dominant and subordinate. Social behavior, such as group hierarchy and dominance, can also influence mating readiness (Ungerfeld, 2021). On the other hand, Kumar *et al.* (2017) studied that rams when exposed to multiple stressors generally increased reaction time, and the number of services to the first ejaculation. In addition, the quality of sperm characteristics and testosterone content decreased, and the libido of rams under stress was reduced. So stress reduction is important to maintain the libido required for the reproductive success of rams (Kumar *et al.*, 2017).

Puberty in lambs

The use of young rams as brood stock in sheep herds occurs every time at younger ages, which causes a reduction in the generational interval (Pacheco *et al.*, 2009). Therefore, it is important for lambs to start puberty as early as possible. Puberty can be defined as the moment in which the lamb is capable of producing male gametes with fertilizing capacity (Zarazaga, 2020). Some data regarding the onset of puberty of hair rams in the literature are shown in Table 1.

The lambs with the longest time until beginning puberty were those of the West African and Santa Inés breeds; those with the less time until puberty were the lambs of the Pelibuey breed. In addition, it can be observed that there is a close direct relationship between age and body weight (Table 1).

Breed

In the different breeds of rams there is variability in physical and reproductive traits. Specifically, there are notable differences in semen characteristics. Table 2 shows that the rams Katahdin, Dorper (both from Mexico) and Santa Inés (from Brazil) have a larger scrotal circumference compared to the Blackbelly and Pelibuey males (from Mexico), and the Colombian breeds Criollo de Pelo and Katahdin. However, rams of the Santa Inés, Blackbelly and Pelibuey breeds had best semen characteristics. The breed Colombian Criollo de Pelo (OPC) had the smallest scrotal circumference; likewise, together with OPC, Saint Croix rams had the lowest sperm concentrations. Sperm abnormalities were higher in Criollo de Pelo rams from Colombia and Brazilian Somali breed (Table 2).

Age

As noted above, the use of rams as brood stock in herds occurs at increasingly younger ages; however, those young animals do not have the phenotype and semen characteristics of an adult ram. In general, young rams initiate puberty at six or seven months with a body weight ranging from 25 to 35 kg (Aké-López *et al.*, 2017). Table 3 shows the scrotal circumference and semen characteristics of young and adult hair rams, as reported in the literature.

Table 1. Age at puberty, body weight, scrotal circumference, and sperm abnormalities in hair lambs.

Breed	Place	Age (days)	BW (kg)	SC (cm)	C ($\times 10^6$ mL^{-1})	SA (%)	Reference
PB	Edo. México, Mexico	143.8±2.2	33±3.6	25.7±1.6	50	18.8±14.8	Valencia-Méndez *et al.* (2005).
SI	Espíritu Santo, Brazil	210.8±50.8	36.3±9.2	25.2±3	281.3±230.3	49.9±16.5	Alves *et al.* 2006).
STC	Nuevo León, Mexico	180	34.7±0.5	27.3±0.3	126±200	-	Ledezma-Torres *et al.* (2022).
OPC	Orinoquia, Colombia	180	15	12	200±180	18.4	Chacón *et al.* (2019).
WA	Zulia, Venezuela	330±0.5	24.2±0.7	24±1.4	422.5±165.2	73.3±12.1	Rodríguez-Urbina *et al.* (2001).

BW: Body weight; SC: scrotal circumference; C: sperm concentration; SA: sperm abnormalities; Breed: PB, Pelibuey; SI, Santa Inés; STC, Saint Croix; OPC, Ovino de Pelo Colombiano; WA, West African.

Table 2. Average (SE) of scrotal circumference and semen characteristics in adult hair rams of distinct breeds.

Breed	Place	SC (cm)	VOL (mL)	MM (1-5)	IM (%)	C ($\times 10^6$ mL^{-1})	SA (%)	Reference
PB	Yucatán, Mexico	31.4±0.2	0.5±0.0	4.5±0.1	86.2±1.5	2963.8±103	5.6±1.3	Aguirre *et al.* (2007); Cárdenas-Gallegos *et al.* (2012).
SI	Northeast Brazil	34.2±2.1	0.9±0.6	4.0±0.7	77.0±26.4	3018±1405	19.4±9.5	Maia *et al.* (2011).
STC	Nuevo León, Mexico	32.3±0.2	1.1±0.0	2.6±0.0	52.9	187.5±8.8	2.1	Santos *et al.* (2015); Sánchez-Dávila *et al.* (2019); Sanchez-Davila *et al.* (2020).
OPC	Sampués, Colombia	27.0	1.2±0.1	3.7±0.1	74.0±2.0	711.8±133	23.3±1.9	Carrillo-González y Hernández, (2016).
WA	Zulia, Venezuela	32.1	-	3.9	90.0	3436	5.1	de Cambellas, (1993).
BY	Yucatán, Mexico	32.6±0.2	0.5 ± 0.0	4.5±0.1	84.7±1.7	3058.7±114	4.7±1.4	Cárdenas-Gallegos *et al.* (2012).
DR	Yucatán, Mexico	34.6±0.2	0.6 ± 0.0	4.4±0.1	83.4±1.5	2960±102	12.4± 1.3	Cárdenas-Gallegos *et al.* (2012).
DR	Northeast Brazil	34.5±1.2	1.1 ± 0.2	4.0±1.4	72.0±26.8	2250±426.4	16.6±7.8	Maia *et al.* (2011).
KN	Yucatán, Mexico	35.0±0.2	0.6 ± 0.0	4.1±0.1	79.9±1.6	2572±105	107±1.3	Cárdenas-Gallegos *et al.* (2012).
KN	Orinoquia, Colombia	27.6±0.2	0.7±0.1	-	80±10	1510±175	-	Chacón *et al.* (2019).
MN	Caerá, Brazil	-	0.2	1.8	50	520	3.5	Mendes Silva *et al.* (2010).
SB	Caerá, Brazil	-	0.4	1.9	70	1570	18.0	Silva y Nunes, (1987).

SE: standard error; SC: scrotal circumference; VOL: volume; MM: mass motility; IM: individual motility; C: sperm concentration; SA: sperm abnormalities. Breed: PB: Pelibuey; SI: Santa Inés; STC: Saint Croix; OPC: Ovino de Pelo Colombiano; WA: West African; BY: Blackbelly; DR: Dorper; KN: Katahdin; MN: Morada Nova; SB: Brazilian Somali.

In general terms, the young rams of Pelibuey, Santa Inés, Criollo de Pelo Colombiano and West African have an average scrotal circumference 6.1 cm smaller than adults of the same breed. Within breeds, scrotal circumference in young Pelibuey rams was 2.5 cm smaller than in adults. Meanwhile, in the young rams of Santa Inés, West African and Criollo de Pelo Colombian, the respective differences in scrotal circumference were 9.0, 8.1 and 4.7 cm smaller in young than adults. The ejaculate volume was similar in all breeds, with no distinction between young and adult rams.

In terms of mass and individual motility between and within breeds, young rams performed better than adults; however, sperm concentration was higher in adults compared to young rams (1435.16 *vs.* 2193.2$\times 10^6$ mL^{-1}). Finally, young West African and Santa Inés rams had the highest percentage of sperm abnormalities.

Table 3. Scrotal circumference and semen characteristics in hair lambs (young) and rams (adult).

Breed	Age	Place	SC (cm)	VOL (mL)	MM (1-5)	IM (%)	C ($\times 10^6$ mL^{-1})	SA (%)	Reference
PB	Y	Yucatán, Mexico	29.4±0.8	0.63±0.3	4.7±0.1	88±0.8	2535±60.7	3.8±0.9	Aké-López *et al.* (2016).
	A		31.9±0.8	0.48±0.3	4.4±0.1	84.8±0.8	2849.8±60.7	6.1±0.9	
SI	Y	Northeast Brazil	25.2±3	0.5±0.2	4.2±0.9	76.5±10.3	1340.5±269.6	49.9±16.5	Pacheco *et al.* (2009).
	A		34.2±2.1	0.9±0.6	4.0±0.7	77±26.4	3018.0±1405	19.4±9.5	Maia *et al.* (2011).
OCP	Y	Orinoquia, Colombia	22.3	0.5±0.1	-	80±10	430±35	-	Chacón *et al.* (2019)
	A	Sampués, Colombia	27.0	1.4±0.1	3.7±0.1	74.0±2.0	711.8±133	23.3±1.9	Carrillo-González y Hernández (2016).
WA	Y	Zulia, Venezuela	24.0±1.4	0.4±0.2	1.6±0.2	89.9±8.1	422.5±165.2	73.3±12.1	Rodríguez-Urbina *et al.* (2001).
	A		32.1	-	-	90.0	3436	5.1	de Cambellas, (1993).

SC: scrotal circumference; VOL: volume; MM: mass motility; IM: individual motility; C: sperm concentration; SA: sperm abnormalities. Breed: PB, Pelibuey; SI, Santa Inés; OPC, Ovino de Pelo Colombiano; WA, West African; Y: young (lambs), 9.0±0.3 months; A: adult (rams), 34.0±6.9 months.

Seasonal condition

The reproductive activity of sheep breeds in regions near the equator or tropical regions is strongly influenced by temperature, rainfall and availability of forage for food (Scaramuzzi et al., 2006). Table 4 shows semen characteristics of hair rams in different seasons due to humidity conditions, in two studies established in 2012 and 2014.

For the breeds evaluated in Mexico, scrotal circumference was similar in the seasons (Table 4). In the ejaculate volume, the Santa Inés breed (Brazil) had an average of 0.22 mL more than Pelibuey rams (Mexico). Regarding mass and individual motility, Pelibuey rams had better characteristics than Santa Inés rams. In addition, in Pelibuey rams MM and MI were higher in the dry season, the opposite was true in Santa Inés rams, since these

Table 4. Seasonal effect on scrotal circumference and semen characteristics of hair rams in tropical regions.

Season†	Place	SC (cm)	VOL (mL)	MM (1-5)	IM (%)	C ($\times 10^6$ mL^{-1})	SA (%)	Reference
Dry	Yucatán, Mexico	33.6±0.2	0.6±0.0	4.5±0.0	85.0±1.4	3295.1±93.9	8.0±1.2	Cárdenas-Gallegos *et al.* (2012)
Dry	Teresina, Brazil	-	0.7±0.1	3.1±0.3	74.2±4.5	2520±30	29.6±2.6	Frazão-Sobrinho *et al.* (2014)
Humid	Yucatán, Mexico	33.1±0.2	0.5±0.0	4.4±0.0	84.2±1.4	2615.4±90.7	10.1±1.1	Cárdenas-Gallegos *et al.* (2012)
Humid	Teresina, Brazil	-	0.8±0.1	3.3±0.5	77.4±3.6	2110±40	21.4±3.5	Frazão-Sobrinho *et al.* (2014)

† Warm climate, in dry or humid condition. In Mexico, the dry season is observed from spring to early summer, while the humid season occurs from mid-summer to early autumn. On the other hand, in Brazil, the humid season spans from January to April, while the dry season is from August to November. SC: scrotal circumference; VOL: volume; MM: mass motility; IM: individual motility; C: sperm concentration; SA: sperm abnormalities.

variables were higher in the rainy season. Sperm concentration was higher in Pelibuey rams compared to Santa Inés rams in both seasons. Regarding the relationship with the weather condition, in the hot and dry season the sperm concentration was higher than in the rainy season, and this occurred in the two ram breeds (Cárdenas-Gallegos *et al.*, 2012; Frazão-Sobrinho *et al.*, 2014).

On the other hand, sperm abnormalities were higher in Santa Inés (Brazil) than in Pelibuey (Mexico), 25.5 *vs.* 9.05% in both seasons. In addition, Pelibuey rams had fewer sperm abnormalities in the dry condition than Santa Inés rams; the opposite happened in the rainy season (humid condition). Overall information shown in Table 4 suggests that rams of the two sheep breeds have a good reproductive capacity in the two seasons of the year defined by humidity (Cárdenas-Gallegos *et al.*, 2015).

CONCLUSIONS

Nutrition affects sperm and testosterone production. In turn, libido is strongly influenced by the presence of testosterone, diseases, length of the day and weather conditions. The onset of puberty in hair rams occurs between 143 and 210 days of age, weight of 15 to 36 kg, scrotal circumference of 12 to 27 cm and with sperm concentrations between 50 and 281×10^6 mL^{-1}. Due to the magnitude of variation between breeds, reports were found of rams with scrotal circumferences of 27-35 cm; ejaculate volume (0.2-1.2 mL), mass motility (1.8-4.5); individual motility (52.9-90.0%), sperm concentration of (187.5 to 3436×10^6 mL^{-1}), and sperm abnormalities (2.1-23.2%). With documented evidence that semen quality is lower in young rams compared to adults.

When reproductive and sperm traits were cross-referenced with seasonality, records were found indicating that in the dry season the reported average characteristics are 33.6 cm of scrotal circumference; 0.7 mL of ejaculate volume; 3.8 of mass motility, 79.6% of individual motility; and sperm concentration of 2907×10^6 mL^{-1}. While, in the humid season, the average values in the literature are 33.1 cm of scrotal circumference; no changes in ejaculate volume, mass motility, or individual motility; and lower average sperm concentration (2362×10^6 mL^{-1}).

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