

INFLUENCE OF MALE-TO-FEMALE RATIO AND CLIMATIC CONDITIONS ON THE REPRODUCTIVE PERFORMANCE OF ANGLO NUBIAN GOATS¹

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ABSTRACT: The objective of this study was to test the “male effect” on the reproductive performance of Anglo Nubian does (n = 180), aged between 24 and 60 months, under different male-to-female ratios (1:20 - T20, 1:30 - T30, and 1:40 - T40) and climatic conditions (dry season - DS, and rainy season - RS). Does were randomly distributed into three groups (T20, T30, and T40) and were isolated from bucks at a distance of 300 m for 60 days before the start of the experiments. The first manifestation of estrous during the DS occurred 6.83 ± 4.54 (T20), 6.72 ± 4.56 (T30) and 7.05 ± 5.23 (T40) days following the onset of the breeding season ($P > 0.05$). In the RS, onset of estrous was observed 6.60 ± 4.74 (T20), 6.70 ± 4.43 (T30) and 7.46 ± 4.54 (T40) days after the beginning of the breeding season ($P > 0.05$). Estrous induction in females during the DS occurred in 95% (T20), 80% (T30), and 75.5% (T40) of all females. During the RS, estrous detection reached 100% (T20), 100% (T30), and 97.5% (T40) of all females, with no difference between all RS and DS groups. Estrous synchronization during the DS occurred in 35.00% (T20), 36.66% (T30), and 32.50% (T40) of all females, for an average occurrence of 34.72%. During the RS, synchronization occurred in 65% (T20), 70% (T30) and 62.25% (T40) of all females, for an average occurrence of 65.75%; no difference was detected between the RS and the DS. Pregnancy rates in the DS groups were 65.0% (T20), 70.0% (T30), and 62.5% (T40), while pregnancy rates in the RS were 90.0% (T20), 86.6% (T30), and 95.0% (T40). No difference was observed for conception rates between any of the RS and DS groups. Prolificacy during the DS was 1.30 (T20), 1.30 (T30) and 1.35 (T40), while in the RS prolificacy was 1.29 (T20), 1.25 (T30) and 1.30 (T40). Thus, the male effect can be used effectively for goats under 1:20-1:40 male-to-female ratios in a 45-day mating season under varying climatic conditions.

Keywords: biostimulation, goats, male effect.

INFLUÊNCIA DA PROPORÇÃO MACHO/FÊMEA E CONDIÇÕES CLIMÁTICAS SOBRE A PERFORMANCE REPRODUTIVA DE CAPRINOS ANGLO-NUBIANOS

RESUMO: O objetivo do presente trabalho foi testar o “efeito macho” sobre o desempenho reprodutivo de cabras Anglo Nubianas (n = 180), com idade entre 24 e 60 meses, sob diferentes proporções macho:fêmea (1:20 - T20, 1:30 - T30, e 01:40 - T40) e condições climáticas (estação seca - ES, e estação chuvosa - EC). As fêmeas foram distribuídas aleatoriamente em três grupos (T20, T30 e T40), e foram mantidas separadas dos machos a distância de 300 m por 60 dias antes do início do experimento. A primeira manifestação de estro na ES ocorreu $6,83 \pm 4,54$ (T20), $6,72 \pm 4,56$ (T30) e em $7,05 \pm 5,23$ (T40) dias após o início da época de reprodução ($P > 0,05$). Na EC, o início do estro foi observado $6,60 \pm 4,74$ (T20), $6,70 \pm 4,43$ (T30) e $7,46 \pm 4,54$ (T40) dias após o início da época de reprodução ($P > 0,05$). A indução de estro na ES chegou em 95% (T20), 80% (T30), e 75,5% (T40) das

fêmeas. Na EC, a detecção do estro atingiu 100% (T20), 100% (T30), e 97,5% (T40), sem diferença entre as épocas do ano. Sincronização de estro durante ES ocorreu em 34,72%, 35,00% (T20), 36,66% (T30), e 32,5 % (T40) das fêmeas. Na EC, a sincronização ocorreu em 65,75% das fêmeas, 65% (T20), 70% (T30) e 62,25% (T40), sem apresentar diferença estatística ($P>0,05$) entre EC e ES. A taxa de gestação nos grupos ES foi de 65,0% (T20), 70,0% (T30), e 62,5% (T40), enquanto que em EC foi de 90,0% (T20), 86,6% (T30), e de 95,0% (T40), sem diferença estatística ($P>0,05$) entre EC e ES. A prolificidade durante ES foi 1,30 (T20), 1,30 (T30) e 1,35 (T40) e na EC foi 1,29 (T20), 1,25 (T30) e 1,30 (T40). Em conclusão, o efeito macho pode ser utilizado com as proporções 1:20-1:40 macho:fêmea, em estação de monta de 45 dias de duração sob condições climáticas diferentes.

Palavras-chave: bioestimulação, cabras, efeito macho.

INTRODUCTION

Goat production is an economically significant activity in many parts of the world, such as South America (particularly Brazil), Africa, and Asia. The majority of goat producers in these regions rely primarily on rearing their stock on native pasturelands, with limited adoption of modern livestock management practices (e.g., mating control). Meat and milk production yields are low and variable under these circumstances, rendering the profit potential questionable (MEDEIROS *et al.*, 1994).

The ever-growing demand for goat products reinforces the need for the implementation and refinement of more sophisticated management practices and their integration with traditional production systems in order to improve income potential (SAMPAIO *et al.*, 2006). The benefits of modern techniques such as estrous synchronization, artificial insemination, and embryo transfer for goat production are well established, but implementing these procedures in regions such as northeast Brazil or Africa is economically and technically challenging due to the relative inefficiency of traditional goat production systems (MOBINI *et al.*, 2005). The limited capacity of producers to invest in expensive new technologies, combined with the high cost of the hormones and associated equipment and materials required to induce and synchronize estrous, are factors that hinder the wider utilization of such procedures (SIMPLÍCIO *et al.*, 2002). In addition, producers are often reluctant to incorporate the use of hormones into production systems because of the increasing consumer demand for hormone-free animal products (SOLIS, 2008).

The “male effect” technique, a procedure that induces and synchronizes estrous naturally in females, is a potential alternative to hormone-based protocols (CHEMINEAU, 1983; LIMA *et al.*, 2000; Horta and GONÇALVES, 2006). Removing bucks from a flock

and then reintroducing them three or four weeks later increases LH pulsatile frequency and induces estrous behavior, and subsequent ovulation, in does (WALKDEN-BROWN *et al.*, 1999; CHEMINEAU *et al.*, 2006). This simple breeding practice can yield homogeneous clusters of offspring, resulting in more consistent and less costly milk and meat production (HORTA and GONÇALVES, 2006; LIMA, 2006).

According to CHEMINEAU (1987), reproductive activity can be stimulated effectively by increasing the proportion of sexually active males within a flock, which induces more females to estrous and subsequent ovulation. It is still necessary, however, to maintain a male-to-female ratio between 5% and 10% to maximize the reproductive potential of the flock.

The objective of the present research was to test the male effect on goat reproductive behavior and performance under various male-to-female ratios and contrasting climatic conditions.

MATERIAL AND METHODS

The experiments were conducted in Sertânia (latitude 8°05'S 37°16'W; altitude 558 meters), a city in the Brazilian state of Pernambuco. Sertânia is hot and semi-arid, with an average annual temperature of 25°C and average annual precipitation of 431 mm. Although the rainy season extends from February to June, the majority of rainfall occurs in March and April.

Adult Anglo Nubian bucks ($n = 3$) were separated from does 60 days before the start of the mating season and were kept in individual pens at a distance of 300 meters from the females to prevent visual, auditory and olfactory contact between the sexes. In both the dry season (DS) and the rainy season (RS), food supplied to the bucks consisted of hay (*Pennisetum purpureum*, Schum.), 0.2 kg of a food supplement concentrate specifically

formulated for goats (DuRancho®, Rancho Alegre, Recife, Pernambuco, Brazil), and 0.2 kg of grain corn (*Zea mays*, L). Does were permitted to graze in the morning in pastures consisting of native caatinga vegetation and cultivated grass (*Cenchrus ciliaris*, L.). During the breeding season, bucks were allowed to graze with their respective female lot. Bucks and does both received additional grass silage (*Pennisetum purpureum*, Schum.) during the DS, and all animals were given unrestricted access to mineral salts and water.

Bucks were subjected to an andrologic evaluation one day prior to the beginning of the mating season, as recommended by CBRA (1998), to ascertain their reproductive status. Upon being introduced randomly into a flock, bucks were marked in the breastbone region with a mixture of grease and dye (4:1) every ten days to score females in estrous. Goats were observed for one hour twice daily (6:00 and 16:00) by trained personnel for signs of estrous behavior.

A flock of 180 pluriparous Anglo Nubian does were individually identified by numbered plastic ear rings and randomly distributed among treatments. They were weighed and scored for their physical condition, as previously described by GONZALEZ-STAGNARO (1991). Female reproductive status was evaluated by ultrasound (as proposed by SANTOS *et al.* (2004)) and vaginoscopy (adapted for goats by GRUNERT *et al.* (2005ab) one day prior to the beginning of the mating season. Serum concentrations of progesterone (P4), determined by chemiluminescence, were used to evaluate the stage of estrous; females that showed a P4 concentration higher than 1 ng/mL were scored as cycling (MORALES *et al.*, 2003). Samples of blood serum were collected the day before the onset of the mating season and were stored at -20°C.

The DS was considered to last from September 9th to October 24th, and the RS breeding season from March 6th to April 20th. Animals were randomly allocated to experimental groups according to the following male-to-female ratios: 1:20 (T20), 1:30 (T30) and 1:40 (T40).

Pregnancy diagnosis was conducted by ultrasound sixty days after the last detection of estrous (SANTOS *et al.*, 2004).

The results were analyzed using descriptive statistics. The student's t-test (T) was used to compare averages, whereas chi-squared and Fisher's exact tests were used to compare binomial data. The level of significance was set at 5% for all statistical tests.

RESULTS

The average weights of the females at the start of

each treatment conducted during the DS were 37.5 kg (T20), 36.80 kg (T30) and 36.40 kg (T40), while the average weights of the females at the start of each treatment conducted during the RS were 37.35 kg (T20), 36.80 kg (T30) and 36.44 Kg (T40).

During the DS, incidence of estrous occurred up to the 25th day of the 45-day mating season (Figure 1). The highest concentration of estrous was observed up to the 10th day in all treatments, with no difference (P>0.05) between groups. During the first five days of the mating season, 34.72% of the females displayed synchronized estrous, with 35.00% in T20, 36.66% in T30 and 32.50% in T40. Similar patterns were observed during the RS (Figure 2). However, in this season, the highest concentration of estrous occurred up to the 5th day in all treatments, regardless of the male-to-female ratio. In the first five days of the mating season, 65.75% of the does displayed synchronized estrus, with 65% in T20, 70% in T30 and 62.25% in T40.

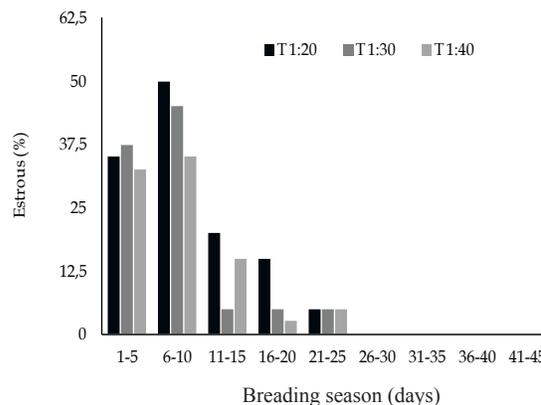


Figure 1. Distribution of estrous in Anglo Nubian goats using different male-to-female ratios in a 45-day breeding season during the dry season.

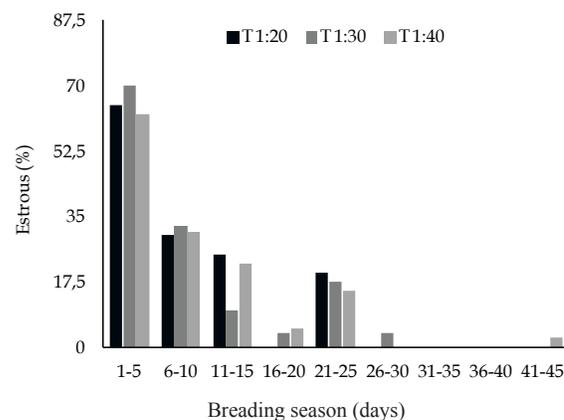


Figure 2. Distribution of estrous in Anglo Nubian goats using different male-to-female ratios in a 45-day breeding season during rainy season.

Several does showed signs of estrous on the first day of exposure to bucks, independent of the male-to-female ratio or prevailing climatic conditions (Table 1). The average time between the onset of the breeding season and first estrous was similar among groups.

The total percentage of estrous during the DS was 95% (T20), 80% (T30), and 75% (T40); during the RS, and the total percentage of estrous was 100% (T20), 100% (T30) and 97.50% (T40). There was no significant difference between these periods (Table 2).

P4 serum concentration was determined as a biochemical assay for reproductive cyclicity (Table

3). P4 concentrations were lower in all treatments during the DS as compared to the RS, but there were also few cyclic females in all treatments during the DS only (Table 3). Pregnancy rates during the DS were 65.0% (T20), 66.6% (T30) and 62.5% (T40), with no significant difference ($P>0.05$) between treatments (Table 4). Pregnancy rates during the RS were 90.0% (T20), 86.6% (T30) and 87.5% (T40), and there was no significant difference ($P>0.05$) between the treatments. Prolificacy during the DS was 1.30 (T20), 1.30 (T30) and 1.24 (T40), while during the RS, prolificacy was 1.29 (T20), 1.25 (T30) and 1.30 (T40) ($P>0.05$).

Table 1. Time to first estrous of Anglo Nubian female goats subjected to the male effect under different climatic conditions and male-to-female ratios of 1:20 (T20), 1:30 (T30) and 1:40 (T40)

Season	Treatment	Time to manifestation of first estrous (days)		
		Minimum	Maximum	Average ¹
Dry	T20	1	19	6.83 ± 4.57
	T30	1	20	6.72 ± 4.56
	T40	1	21	7.05 ± 5.23
Rainy	T20	1	21	6.60 ± 4.74
	T30	1	23	6.70 ± 4.43
	T40	1	23	7.46 ± 4.54

¹No significant difference was observed ($P>0.05$).

Table 2. Incidence of different estrous types of Anglo Nubian female goats subjected to the male effect under different climatic conditions and male-to-female ratios of 1:20 (T20), 1:30 (T30) and 1:40 (T40)

Estrous Type	Season					
	Dry			Rainy		
	T20	T30	T40	T20	T30	T40
Single estrous	11 (57.80%)	18 (75.00%)	22 (73.30%)	13 (65.00%)	19 (63.34%)	24 (61.53%)
Short cycle (<17 days)	8 (42.10%)	6 (25.00%)	8 (26.66%)	6 (30.00%)	8 (26.66%)	12 (30.76%)
Normal cycle (17-25 days)	-	-	-	1 (5.00%)	3 (10.00%)	3 (7.69%)
Total	19 (95.00%)	24 (80.00%)	30 (75.00%)	20 (100.00)	30 (100.00%)	39 (97.50%)

No significant difference was observed ($P>0.05$).

Table 3. Progesterone (P4) concentrations in the blood of Anglo Nubian female goats subjected to the male effect under different climatic conditions, cyclicity conditions and male-to-female ratios of 1:20 (T20), 1:30 (T30) and 1:40 (T40)

Season	Treatment	Number of animals	P4 (ng/mL)	Cyclicity	
				Cyclic	Acyclic
Dry	T20	20	0.64 ± 0.48 a	3 (15.0%) a	17 (85.0%) a
	T30	30	0.70 ± 0.50 a	6 (20.0%) a	24 (80.0%) a
	T40	40	0.64 ± 0.52 a	7 (17.5%) a	33 (82.5%) a
Rainy	T20	20	1.23 ± 0.42 b	18 (90.0%) a	2 (10.0%) b
	T30	30	1.28 ± 0.44 b	27 (90.0%) a	3 (10.0%) b
	T40	40	1.24 ± 0.45 b	34 (85.0%) a	6 (15.0%) b

Different capital letters in the same column indicate significant differences (P<0.05) by chi-squared and Fisher's exact tests.

Table 4. Pregnancy rates of Anglo Nubian goats subjected to the male effect under different climatic conditions and male-to-female ratios of 1:20 (T20), 1:30 (T30) and 1:40 (T40)

Pregnancy	Season					
	Dry			Rainy		
	T20	T30	T40	T20	T30	T40
First estrous	8 (72.72%)	14 (77.77%)	20 (90.90%)	12 (92.30%)	18 (94.73%)	22 (81.48%)
Second estrous	5 (62.50%)	6 (100.00%)	5 (62.50%)	6 (85.71%)	6 (85.71%)	11 (91.66%)
Third estrous	-	-	-	-	2 (66.66%)	2 (66.66%)
Total	13 (65.00%)	20 (66.60%)	25 (62.50%)	18 (90.00%)	26 (86.60%)	35 (87.50%)

No significant difference was observed (P>0.05).

DISCUSSION

The potency of the male effect is proportional to anestrus intensity: the higher the anestrus intensity, the lower the frequency of estrus and the higher the incidence of short estrus cycles produced in response to the male effect (CHEMINEAU, 1983, 1987). The results found in the present research were in accordance with this model during the DS, which is the season when most goats were acyclic (confirmed by low P4 concentration). However, the incidence of short estrus cycles was not affected by either cyclic or acyclic conditions. Physiologically, estrus cycles in small ruminants are highly variable in duration, and under conditions of gonadotropin deprivation, precocious corpus luteum regression

ultimately leads to short estrus cycles. However, under the male effect, LH release is substantially increased even in cycling females (ABECIA *et al.*, 2012), possibly leading to improved quality of corpus luteum regardless of cyclicity conditions.

The male effect, independent of the male-to-female ratio, was shown to be effective in stimulating reproductive activity in goats, especially in the RS, during which estrus synchronization in females ranged from 60% to 70%. This outcome is in contrast with recommendations by CHEMINEAU (1987). The introduction of a male to an isolated, female-only flock triggers a pre-ovulatory LH peak that stimulates final follicular development, oocyte maturation, and subsequently induces ovulation (SHELTON, 1960; MARTIN *et al.*, 1986; CHEMINEAU, 1987;

LIMA *et al.*, 2000), even in cycling females (ABECIA *et al.*, 2012). This phenomenon suggests that the male effect may induce an incidence of estrous within the first ten days of a breeding season equal to that attained through the application of pharmacological substances, such as luteolytic (LIMA *et al.*, 2000).

One factor that may have contributed to the rapid manifestation of estrous after exposure to males is the lack of reproductive seasonality in small ruminants under tropical conditions, as is prevalent in northeastern Brazil, combined with the fact that the male effect induces gonadotropins that support rapid follicular growth, followed by estrous and ovulation (MARTIN *et al.*, 1986; CHEMINEAU, 2006). It is also important to note that the more remarkable results obtained during the RS could be due to the quality of available food. Although supplemental grass silage was included in the animals' diet in the DS, it may not have been sufficient to overcome nutritional deficits, particularly of nutrients (such as β -carotene) that aid in corpus luteum formation and function (LOTHAMMER, 1979; ANDRIGUETTO *et al.*, 2004).

It has been shown previously that a breeding season ranging from 15–25 days is sufficient to obtain high pregnancy rates in Anglo Nubian goats (SHELTON, 1960; OTT *et al.*, 1980; LIMA, 2006; LUNA-OROZCO *et al.*, 2008; ALMEIDA-IRMÃO *et al.*, 2009). The present research offers further support for this observation, based on the fact that, because of the variable duration of the estrous cycle in goats, two or more estrus can be detected in a period of 35 days (CHEMINEAU, 1983; CHEMINEAU *et al.*, 1986; LIMA *et al.*, 2000; JAINUDEEN *et al.*, 2004). Pregnancy rates were similar between groups. The results of the initial series of matings were similar to those of FOLCH *et al.* (1993); it is clear, therefore, that the first ovulation in goats can be fertile, as noted by CHEMINEAU (1987). In general, pregnancy rates and prolificacy were not influenced by the male-to-female ratio, reinforcing the perspective that all male-to-female ratios tested are sufficient for generating high rates of pregnancy.

In conclusion, the male effect can be used effectively for goats under 1:20-1:40 male-to-female ratios in a 45-day mating season under varying climatic conditions, if some critical requirements – such as nutrition, body score condition, body weight and postpartum period – are met.

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