

## ANNUAL CHARACTERISTICS OF ESTROUS ACTIVITY IN WOOL AND HAIR EWE LAMBS UNDER SUBTROPICAL CONDITIONS

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**ABSTRACT:** The increased emphasis placed on lamb production in Brazil points to the need for a better knowledge of the annual pattern of reproductive activity in ewe lambs. This study evaluates the annual estrous activity pattern of hair and wool ewe lambs raised in southeast Brazil. Estrous characteristics were recorded for 12 months in ten Santa Inês and 21 Romney Marsh and Suffolk ewe lambs. Santa Inês ewe lambs exhibited a greater length of the normal estrous cycle (14 to 19 days) than Romney Marsh and Suffolk ewe lambs ( $17.0 \pm 0.1$  days vs.  $16.5 \pm 0.2$  and  $15.9 \pm 0.2$  days). All the ewe lambs presented a greater number of periods of estrus per animal per month for single estrous cycles (up to 26 days) during autumn and winter. During spring and summer there was a reduction of this number but this decline varied according to the breed. For Santa Inês ewe lambs the reduction was only significant in the summer. For wool ewe lambs the reduction was significant in both seasons but was more accentuated for Romney Marsh. The Romney Marsh ewe lambs had a more restricted breeding season than Suffolk and both presented optimal estrus activity in autumn and winter. Santa Inês ewe lambs had a continuous distribution of estrous cycles along the year, although presenting a reduction in the number of estrous periods in the summer. The ewe lambs of three breeds presented characteristics of sexual immaturity, like irregular estrous cycles and silent ovulations.

**Key words:** breeds, estrous cycle, sheep, subtropics, seasonality

## CARACTERÍSTICAS ANUAIS DA ATIVIDADE ESTRAL EM BORREGAS LANADAS E DESLANADAS MANTIDAS SOB CONDIÇÃO SUBTROPICAL

**RESUMO:** Em função do maior interesse pela ovinocultura de corte na região Sudeste do Brasil há necessidade de conhecer melhor o padrão anual da atividade reprodutiva das borregas. Esse estudo avaliou esse padrão anual em borregas deslanadas e lanadas criadas nessa região. A atividade cíclica reprodutiva foi avaliada durante 12 meses em dez borregas da raça Santa Inês e 21 borregas das raças Romney Marsh (11) e Suffolk (10). A duração dos ciclos estrais normais (14 a 19 dias) das fêmeas Santa Inês foi maior do que a duração observada nas fêmeas Romney Marsh e Suffolk ( $17,0 \pm 0,1$  dias vs.  $16,5 \pm 0,2$  e  $15,9 \pm 0,2$  dias). Todas as borregas apresentaram um elevado número de períodos de estros/animal/mês para ciclos estrais simples (até 26 dias) durante o outono e inverno. Houve redução desse número durante a primavera e o verão, mas esse declínio variou conforme a raça. Para as borregas Santa Inês essa redução só foi significativa no verão enquanto que para as fêmeas das raças lanadas, a redução foi significativa em ambas as estações e mais acentuada nas fêmeas Romney Marsh. As fêmeas dessa raça também apresentaram uma estação reprodutiva mais restrita do que as fêmeas Suffolk havendo uma concentração dos estros durante o outono e inverno para as fêmeas de ambas as raças. As fêmeas Santa Inês apresentaram uma distribuição equilibrada dos estros ao longo do ano embora tenha havido uma redução do número de período de estros durante o verão. As borregas das três raças apresentaram características de imaturidade sexual como ciclos estrais irregulares e ovulações silenciosas.

**Palavras-chave:** raça, ciclo estral, ovinos, região subtropical, estacionalidade

## INTRODUCTION

Reproductive activity in sheep is characterized by a seasonality influenced by several factors such as photoperiod, latitude, temperature, nutrition and breed (Hafez, 1952; Mbayahaga et al., 1998). Photoperiod is the main factor that regulates the breeding season of wool sheep in high latitudes in the northern hemisphere, whose period of maximum estrous activity is during autumn and winter (Hafez, 1952). In tropical regions, near the Equator, where there is little variation in the length of day light periods, there is a tendency for native breeds to present reproductive activity along the year (Figueiredo et al., 1980; Girão et al., 1984; Gonzalez-Reyna et al., 1991).

The Brazilian territory extends over a great variation of latitudes (5°16' N to 33°45' S) and the characteristics of the cyclic reproductive activity of ewe lambs varies considerably depending on the region. In the Northeast, the sheep flock is constituted only of hair meat breeds, being Santa Inês the most widespread breed. Their females present cyclic reproductive activity along the year (Figueiredo et al., 1980; Girão et al., 1984). However, in the southern region there is a predominance of wool breeds, specialized for both wool (Merino and Polwarth) and meat production (Corriedale, Romney Marsh and Suffolk). Ewe lambs of such breeds present seasonality of their cyclic reproductive activity (Silva & Figueiró, 1980; Ribeiro et al., 1996).

In the southeastern region sheep breeding for meat production is growing considerably during the last few years (Cunha et al., 2000; Siqueira et al., 2001; Garcia et al., 2003; Rocha et al., 2004; Furusho-Garcia et al., 2004; Silva Sobrinho et al., 2005). The ovine herd is constituted of both wool breeds, such as Suffolk, Ile de France and Texel, and hair breeds, such as Santa Inês. In this region, there is evidence that wool sheep present a certain degree of seasonality in their reproductive activity (Roda et al., 1993), while the Santa Inês ewe lambs present cyclic reproductive activity along the year (Coelho et al., 2001; Boucinhas, 2004). However, there are no thorough studies on seasonal tendencies of reproductive activity in wool and hair sheep in this region as well as information on the peculiarities of annual reproductive activity of ewe lambs.

Additionally, female sheep in the first year after puberty show different characteristics of their estrus cycles when compared to adults (Dyrmondsson, 1973). These include a shorter duration and lower intensity of behavioral estrus and longer or irregular estrus cycles than in ewes (Hafez, 1952; Keane, 1975; Bathaei, 1996). These authors assumed that ovulations without estrus behavior occurred between two overt

estrus periods in estrus cycles longer than 26 days. This event was confirmed by plasma progesterone profiles (Hare & Bryant, 1982; Sasa et al., 2001).

The present study aimed to monitor the annual estrous activity pattern of hair (Santa Inês) and wool ewe lambs (Romney Marsh and Suffolk) and to provide information on the pattern of reproductive seasonality of these breeds in southeastern Brazil.

## MATERIAL AND METHODS

The experiment was conducted in Pirassununga, SP, Brazil, from March 1999 to March 2000. The region is at 21°59' S, 47°26' W; average altitude of 634 m. The climate is subtropical with average annual rain precipitation and temperature of 1,300 mm and 21°C, respectively (Köppen, 1948).

A total of 31 ewe lambs of Santa Inês (n = 10), Romney Marsh (n = 11) and Suffolk (n = 10) breeds were used in the trial. The ewe lambs were 8.3 ± 0.9 months old and the mean (± s.d.) live weights of Santa Inês, Romney Marsh and Suffolk were 45.2 ± 0.8, 42.3 ± 1.6 and 47.7 ± 1.8 kg, respectively. All animals were previously vaccinated and dewormed and then they remained in a confinement system under natural photoperiod conditions. Nutrition was based on concentrate ration, bermudagrass hay (*Cynodon dactylon*), coast-cross cultivar, twice a day, according to the nutritional requirements for breeding sheep (NRC, 1985), and water *ad libitum*.

To identify the ewe lambs in estrus, vasectomized adult rams of Santa Inês breed with no annual variation in breeding behavior, were used during the study. The ewe lambs were maintained in the presence of the males in a proportion of 10:1 during the entire experimental period. The males were alternated every month to minimize the effect of sexual preference. Each ram was marked on its prepucial region with a raddle crayon marking harness (Fogarty et al., 1992). The color of the paint was changed every ten days (Hare & Bryant, 1982). The observation of ewe lambs in estrus was performed twice a day, once in the morning and once in the afternoon. The ewe lambs that were marked in the rump region or allowed the male to mount were considered in estrus.

To verify the occurrence of ovulations without estrus manifestations (silent ovulations), blood samples were collected at the same times in the morning, two to three times a week throughout the year to determine the plasma concentrations of progesterone. The blood samples were centrifuged and the plasma stocked at -20°C until analysis. The samples were analyzed by the radioimmunoassay method (RIA) in duplicate using commercial kits (COAT-A-COUNT, Di-

agnostic Products Company, Los Angeles, CA, USA). The sensibility of the assay was  $0.02 \text{ ng mL}^{-1}$  and the inter- and intra-assay variation coefficients were 2.9 and 1.9% (five assays), respectively.

During the period of data collection, the records of estrus detection by the vasectomized males and by plasma progesterone dosages were confronted for each animal. Estrus was determined by the observation of females marked by the vasectomized males and confirmed by the plasma progesterone concentration values inferior to  $1 \text{ ng mL}^{-1}$  for a period of 36 to 72 h. Hormonal levels above  $1 \text{ ng mL}^{-1}$  characterized the luteal phase of estrous cycle and when the concentrations were inferior to  $1 \text{ ng mL}^{-1}$  for a period superior to ten days, the females were considered in anestrus (Minton et al., 1990).

The evaluated variables were: a) breed variation on the length and incidence of single estrous cycles (up to 26 days) which were divided in short (< 14 days), normal (14 – 19 days) and long (20 – 26 days), and multiple estrous cycles (27 – 57 days) which were divided in double (27 – 37 days) and triple (38 – 57 days), according to Hafez (1952); b) mean number of monthly and seasonal overt periods of estrus (detected by vasectomized males) per animal per month, c) monthly and seasonal mean numbers of silent ovulations per female per month, d) breed variation on duration of breeding season.

The incidence of estrous cycles was defined as the percent of short, normal, long (single) and multiple (double and triple) cycles from the total of single and multiple estrous periods. When assessed by vasectomized males, the double cycles were considered to include one ovulation without estrus manifestation (silent ovulation), and the cycle length was divided in two in order to estimate the occurrence (date) of silent ovulation, while triple cycles were divided in three (Bathaei, 1996).

The duration of the estrus activity period was defined as the period comprehended between the date of the first estrus after the beginning of the experi-

ment and the date of the last observed estrus detected by vasectomized males during thirteen months of observations.

The GLM procedure (SAS, 1995) was used to determine statistical differences in breed for length of the estrous cycle and breeding season duration. These data were calculated using General Linear Models and a Student's *t* test. The mean number of overt periods of estrus per animal per month and the mean number of silent ovulations per female per month were performed according to the GENMOD procedure (SAS, 1995) as repeated measurements using Generalized Linear Models. The following model was used:

$$Y_{ijk} = g(x) = \mu + B_i + M_j \text{ or } S_j + BM_{ij} \text{ or } BS_{ij} + e_{ijk}$$

where  $Y_{ijk}$  is the mean number of overt periods of estrus or the mean number of silent ovulations, the *i*th breed, the *j*th month or *j*th season and  $g(x)$  is the link function (logarithm);  $\mu$  the general mean;  $B_i$  the breed;  $M_j$  the month or  $S_j$  the season;  $BM_{ij}$  or  $BS_{ij}$  the interaction between breed and month or season and  $e_{ijk}$  the residual error. The differences between breeds regarding incidence (%) of single and multiple estrous cycles were analyzed by Chi-Square test.

## RESULTS AND DISCUSSION

The length of single (up to 26 days) and multiple (27 to 57 days) estrous cycles demonstrated in Table 1 showed breed differences ( $P < 0.01$ ) only on the length of normal (14 – 19 days) cycles. The length of normal estrous cycles for Santa Inês ewe lambs was superior to those of Romney Marsh and Suffolk. However, the mean length of irregular single cycles, both short (< 14 days) and long (20 to 26 days), and the mean length of multiple cycles were similar for the three breeds. These results are in agreement with Hafez (1952), who established this classification for sheep estrous cycles. There are very marked breed differences regarding the length of the estrus cycle, which are probably due to genetic differences.

Table 1 - Length of single (up to 26 days) and multiple (27 to 57 days) estrous cycles for Santa Inês, Romney Marsh and Suffolk ewe lambs from March 1999 to February 2000.

Breeds	No. of estrous observations	Estrous cycles (days) (mean $\pm$ s.e.)			
		Single <sup>1</sup>			Multiple
		Short	Normal	Long	
Overall mean	422	11.4 $\pm$ 0.1	16.5 $\pm$ 0.2	22.1 $\pm$ 0.2	36.9 $\pm$ 0.4
Santa Inês	170	11.6 $\pm$ 0.1	17.0 $\pm$ 0.1a	22.4 $\pm$ 0.2	39.3 $\pm$ 0.7
Romney Marsh	116	11.4 $\pm$ 0.2	16.5 $\pm$ 0.2b	21.5 $\pm$ 0.1	37.0 $\pm$ 0.6
Suffolk	136	11.1 $\pm$ 0.1	15.9 $\pm$ 0.2c	22.3 $\pm$ 0.2	34.4 $\pm$ 0.7

<sup>1</sup>Single cycles: short (up to 13 days), normal (14 – 19 days) and long (20 – 26 days). <sup>a, b, c</sup>Values with different subscripts within the column are different ( $P < 0.01$ ) by Student's *t*-test.

However, the length of the estrous cycle is more affected by other factors such as the phase of the breeding season (Ravindra & Rawlings, 1997) and age of the sheep groups (Bathaei, 1996) rather than breed differences. Ravindra & Rawlings (1997), studying the follicular dynamics at the beginning of the sheep breeding season, verified a greater variability in the length of the estrus cycle as well as a lower consistency of follicular emergence in the first estrus cycle when compared to the second one of the breeding season. These facts seem to be related to the plasma concentrations of progesterone detected before the first ovulation of the breeding season, which would be modulating the duration, and/or periodicity of follicular waves and consequently the length of the estrous cycle. This event was reported in sexually mature animals and was also observed in prepubertal female sheep (Foster & Ryan, 1979). The present findings do not allow definitive conclusions regarding breed differences on the length of normal estrous cycle because only 10 to 11 animals per breed were studied but, they probably suggest a genetic variation which is interacting with the age of the animals, as the animals of the present study were young and breed differences could be a consequence of the age. They presented characteristics of reproductive immaturity such as occurrence of irregular estrous cycles and breed differences on the length of estrous cycle are more frequent in ewe lambs than in adult sheep (Hafez, 1952; Foote et al., 1970).

All the ewe lambs showed some incidence of irregular estrous cycles (Table 2). From a total of 422 estrous cycles observed for Santa Inês, Romney Marsh and Suffolk, 84.1% and 15.9% were considered as single (up to 26 days) and multiple (27 to 57 days) cycles, respectively. From the total, 57.6%, 14.0% and 12.6% of the cycles were considered of normal (14 – 19 days), short (up to 13 days) and long (20 – 26 days) lengths, respectively. No breed differences ( $P > 0.05$ ) were observed when each single

group was analyzed separately, but differences were when these data were studied as a whole (single estrous cycles). The Romney Marsh ewe lambs showed higher incidence of single estrous cycles (91.4%) than Santa Inês ewe lambs (78.2%). The Suffolk ewe lambs presented intermediate incidence of single cycles (85.3%) but not different from Santa Inês and Romney Marsh. In all breed groups the incidence of normal estrous cycles was low ranging from 53.5 to 65.5% of the total. These observations confirm the reproductive immaturity of the ewe lambs of the three breeds and they are compatible to the previously mentioned studies.

Additionally, breed differences ( $P < 0.01$ ) on incidence of multiple estrous cycles were also evidenced (Table 2). The occurrence of the multiple cycles was much more frequent in Santa Inês ewe lambs (21.8%) than in Romney Marsh (8.6%). The Suffolk ewe lambs showed an intermediate incidence (14.7%) with no difference from the other breeds. The presence of multiple estrous cycles was considered an indication of presumed ovulations without estrus manifestation (presumed silent ovulations) when the classification of these cycles is only based on estrus detection by vasectomized males. In this case, double (27 to 37 days) and triple (38 to 57 days) cycles were considered one and two silent ovulations between two overt estrus periods (Hafez, 1952; Bathaei, 1996). Actually, the pattern of plasma progesterone confirmed that one silent ovulation occurred in a multiple cycle classified as double, whereas two silent ovulations occurred in a triple cycle (Figure 1). These results are in agreement with previous studies conducted in high (Hare & Bryant, 1982) or low (Sasa et al., 2001; 2002) latitudes.

As the number of silent ovulations was classified per animal per month and evaluated along the year (Figure 2); breed variation ( $P < 0.01$ ) was also observed along the seasons. In general, Santa Inês (0.30 to 0.53 silent ovulations per animal per month)

Table 2 - Incidence of single (up to 26 days) and multiple (27 to 57 days) estrous cycles for Santa Inês, Romney Marsh and Suffolk ewe lambs from March 1999 to February 2000.

Breeds	No. of estrous observations	% of Estrous cycles (no.)				
		Single <sup>1</sup>			Total	Multiple
Short	Normal	Long				
Total	422	14.0 (59)	57.6 (243)	12.6 (53)	84.1 (355)	15.9 (67)
Santa Inês	170	10.0 (17)	53.5 (91)	14.7 (25)	78.2 (133) <sup>a</sup>	21.8 (37) <sup>a</sup>
Romney Marsh	116	14.7 (17)	65.5 (76)	11.2 (13)	91.4 (106) <sup>b</sup>	8.6 (10) <sup>b</sup>
Suffolk	136	18.4 (25)	55.9 (76)	11.0 (15)	85.3 (116) <sup>ab</sup>	14.7 (20) <sup>ab</sup>

<sup>1</sup>Single cycles: short (up to 13 days), normal (14 – 19 days) and long (20 – 26 days). <sup>a, b, c</sup>Values with different subscripts within the column are different ( $P < 0.01$ ) by Chi-square test.

ewe lambs had also a greater seasonal number of silent ovulations than Romney Marsh (0.06 to 0.12 silent ovulations per animal per month) and Suffolk (0.03 to 0.37 silent ovulations per animal per month) in all seasons, except in the winter, when no breed differences were observed.

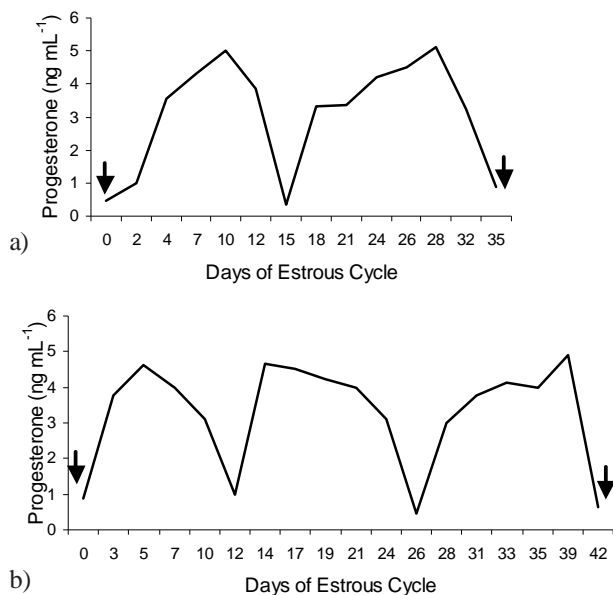


Figure 1 - Plasma progesterone concentration during multiple cycle period of one Santa Inês ewe lamb: (a) one example of a double multiple cycle; (b) one example of a triple multiple cycle. Arrows denote overt estrus.

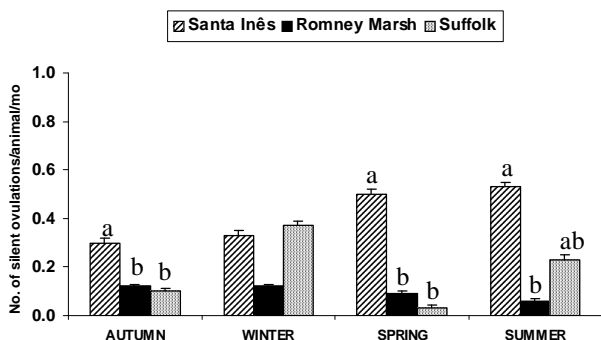


Figure 2 - Seasonal number of silent ovulations (means + s.e.) per animal per month for Santa Inês, Romney Marsh and Suffolk ewe lambs from March 1999 to February 2000. Different letters on bars indicate breed differences within each season by Chi-square test.

The greatest breed differences were evidenced in spring and summer in which the frequency of silent ovulations for Santa Inês ewe lambs reached extremely high values when compared to those observed for the wool ewe lambs. This probably occurred as a consequence of a low frequency of overt estrus behavior in wool ewe lambs during this period as shown in Figure 3 and in Table 3.

According to the monthly variations on the number of overt periods of estrus per animal per month for single estrous cycles (Figure 3), Santa Inês ewe lambs had a lower monthly variability on overt estrous

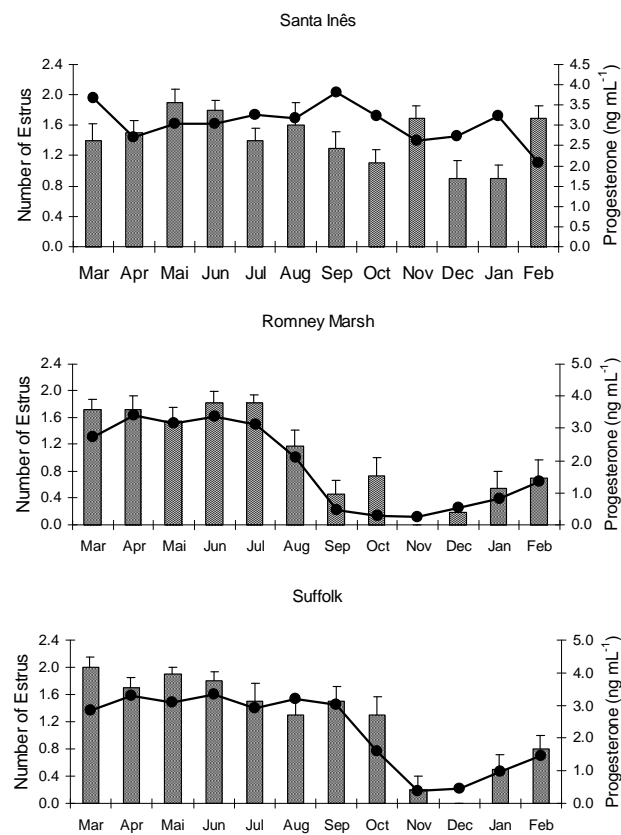


Figure 3 - Monthly number of periods of estrus (means + s.e.) per animal per month for overt single estrous cycles (up to 26 days) and plasma progesterone concentrations (means) for Santa Inês, Romney Marsh and Suffolk ewe lambs from March 1999 to February 2000.

Table 3 - Seasonal variations (means ± s.e.) of the number of periods of estrus per ewe lambs per month for single estrous cycles (up to 26 days) for Santa Inês, Romney Marsh and Suffolk ewe lambs from March 1999 to February 2000.

Breed/Season	Autumn	Winter	Spring	Summer
Santa Inês	1.6 $\pm$ 0.10 <sup>Aa</sup>	1.6 $\pm$ 0.11 <sup>Aa</sup>	1.3 $\pm$ 0.12 <sup>A,Ba</sup>	1.2 $\pm$ 0.13 <sup>Ba</sup>
Romney Marsh	1.6 $\pm$ 0.11 <sup>Aa</sup>	1.6 $\pm$ 0.12 <sup>Aa</sup>	0.3 $\pm$ 0.11 <sup>Bb</sup>	0.4 $\pm$ 0.12 <sup>Bb</sup>
Suffolk	1.9 $\pm$ 0.07 <sup>Aa</sup>	1.5 $\pm$ 0.13 <sup>Aa</sup>	1.0 $\pm$ 0.16 <sup>Ba</sup>	0.4 $\pm$ 0.11 <sup>Cb</sup>

Values with different superscripts within the same row (A, B, C) or within the same column (a, b) are different ( $P < 0.01$ ) by Chi-square test.

activity than the wool ewe lambs. There was a reduction in the occurrence of estrus per animal and even its absence in Romney Marsh and Suffolk ewe lambs during the months of September to December. For Santa Inês, Romney Marsh and Suffolk ewe lambs the estrous activity assessed by vasectomized rams was compatible with the ovulatory activity determined by plasma progesterone concentrations.

Regarding breed and seasonal variations on the number of estrus events per animal per month (Table 3), there was effect of the interaction between breed and season. The mean number of overt estrus was greater ( $P < 0.01$ ) in autumn and winter than in spring and summer for wool ewe lambs than in summer for hair ewe lambs. There were no seasonal and breed differences on the number of estrus between autumn and winter and along both seasons the mean number of estrus ranged from 1.5 to 1.9 estruses per animal per month. The greatest breed and seasonal differences became more evident when both effects were compared in spring and summer. In the spring the mean number of overt estrus in Santa Inês ewe lambs (1.3 estrus per animal per month) was greater ( $P < 0.01$ ) than in Romney Marsh (0.3 estrus per animal per month), but not different from Suffolk (1.0 estrus per animal per month). In the summer the mean number of overt estrus in Santa Inês (1.2 estrus per animal per month) ewe lambs was superior ( $P < 0.01$ ) to Romney Marsh (0.4 estrus per animal per month) and Suffolk (0.4 estrus per animal per month).

These results suggest a distinct seasonal reproductive behavior for wool and hair ewe lambs raised at lower latitudes in the southern hemisphere. This behavior was dependent of the month and/or the season of the year. Estrous activity in hair ewe lambs (Santa Inês) was distributed more regularly along the year with minimum activity in December and January (Figure 2). Although the number of periods of estrus per animal per month was reduced during the summer, all ewe lambs had overt estrous behavior. These results are in agreement with studies performed in the northeastern region ( $3^{\circ}32'S$ ), where hair sheep can be bred more than once a year, during two annual mating seasons (Figueiredo et al., 1980; Girão et al., 1984) and with ewe lambs plasma progesterone profile in southeastern region (Coelho et al., 2006).

In tropical regions there is a tendency for native breeds to present themselves as polyestrous but non-seasonal (Girão et al., 1984; González-Reyna et al., 1992). When some degree of seasonality of reproductive activity is evidenced, it is conditioned to other factors more important than photoperiod, such as rainfall, nutrition, air temperature and humidity (Gonzalez et al., 1992; Galina et al., 1996; Mbayahaga et al.,

1998). More recently, Cerna et al., (2000) and Hernandez et al. (2002) have suggested that the photoperiod would be the main regulator of the reproductive activity in hair sheep bred in the tropics. The present research seems to confirm this latter indication since during the shortest days there was a slight change in the reproductive pattern of Santa Inês ewe lambs, which was translated as a reduction in the number of periods of estrus in summer and a great number of silent ovulations in spring and summer. However, the possibility of other factors interacting with photoperiod such as temperature and age of the animals cannot be ruled out. The temperature could be acting in synergy with the photoperiod since, during the summer, maximum temperatures in this region may reach high values in a range of  $30^{\circ}$  to  $32^{\circ}C$ . In addition, the occurrence of ovulations with estrus behavior seems to be more a consequence of the age than a characteristic of the annual pattern of reproductive activity, which should be extrapolated for mature animals. Conversely, wool ewe lambs presented a distinct pattern of cyclic estrous activity with estrous behavior concentrated during autumn and winter. During spring and summer, these ewe lambs were in low estrous activity or in anestrus. Romney Marsh ewe lambs had a more restricted breeding season than Suffolk ewe lambs. The significance of this difference became more evident during spring when the mean number of estrus per animal was superior for Suffolk than Romney Marsh ewe lambs. Comparing only the wool ewe lambs, the mean duration of the breeding season for Suffolk ( $213.3 \pm 14.8$  days) ewe lambs was longer than for Romney Marsh ( $164.2 \pm 14.1$  days). The values recorded for both wool breed are not intended to be representative of these breeds but rather indicate possible differences due to genotype.

Although the present observations confirm the seasonal reproductive pattern of wool ewe lambs raised along high latitudes in the northern hemisphere (Hafez, 1952; Foote et al., 1970; Keane, 1975; Hare & Bryant, 1982), the duration of the breeding season of both wool ewe lambs raised in the Brazilian subtropical region was quite different from the reports in which the breeding season of wool ewe lambs was extremely restrict (34 to 84 days). It would appear that differences on the duration of breeding season are related to the geographical origin of the breed (Hafez, 1952). It seems that Romney Marsh and Suffolk sheep, which are British breeds originated from high latitudes ( $51^{\circ}$  to  $52^{\circ}N$ ) tend to extended the length of the breeding season when maintained in low latitudes where the variation between the shortest (10.7 hours of day-light) and the longest (13.3) day is only 2.6 hours.

## CONCLUSION

Santa Inês ewe lambs could be considered as sheep with nearly no reproductive seasonality with a greater uniformity in the distribution of estrous cycles along the year, although there was a reduction in the number of estrous periods during summer. Conversely, Romney Marsh and Suffolk ewe lambs presented a seasonal reproductive pattern with maximum activity during autumn and winter. The breeding season of the Romney Marsh however was more restricted than that of Suffolk lambs. The ewe lambs of the three breeds had characteristics of sexually immature animals, such as irregular estrous cycles and occurrence of ovulations without estrus manifestation.

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## REFERENCES

- BATHAEI, S. Breeding season and oestrous activity of Iranian fat-tailed Mehraban ewes and ewe lambs. **Small Ruminant Research**, v.22, p.13-23, 1996.
- BOUCINHAS, C.C. Análise técnica e econômica de dois sistemas de alimentação de ovelhas manejadas para três partos a cada dois anos. Botucatu: UNESP/FMVZ, 2004. 66p. (Tese - Doutorado).
- CERNA, C.; PORRAS, A.; VALENCIA, M.J.; PERERA, G.; ZARCO, L. Effect of an inverse subtropical (19°13N) photoperiod on ovarian activity, melatonin and prolactin secretion in Pelibuey ewes. **Animal Reproduction Science**, v.60, p.511-525, 2000.
- COELHO, L.A.; RODRIGUES, P.A.; NONAKA, K.O.; SASA, A.; BALIEIRO, J.C.C.; VICENTE, W.R.R.; CIPOLLA-NETO, J. Annual pattern of plasma melatonin and progesterone concentrations in hair and wool ewe lambs kept under natural photoperiod at lower latitudes in the southern hemisphere. **Journal Pineal Research**, v.41, p.101-107, 2006.
- COELHO, L.A.; RODRIGUES, P.A.; SASA, A.; CRIVELLENTI, T.L.; SILVA, E.C.F.; MALHEIROS, E.B. Breeding season length of wool and hair ewe lambs under subtropical conditions in Brazil. In: REUNIÓN DE LA ASOCIACIÓN LATINOAMERICANA DE PRODUCCIÓN ANIMAL, 17., Havana, 2001. **Anais**. Havana, 2001. 1 CD-ROM.
- CUNHA, E.A. da; SANTOS, L.E. dos; BUENO, M.S.; RODA, D.S.; LEINZ, F.F.; RODRIGUES, C.F.C. Utilização de carneiros de raça de corte para obtenção de cordeiros precoces para abate em plantéis produtores de lã. **Revista da Sociedade Brasileira de Zootecnia**, v.29, p.243-252, 2000.
- DYRMUNDSSON, O.R. Puberty and early reproductive performance in sheep. I. Ewe lambs. **Animal Breeding Abstract**, v.41, p.273-289, 1973.
- FIGUEIREDO, E.A.D.; OLIVEIRA, E.R.; BELLAVER, C. **Performance dos ovinos deslanados no Brasil**. Sobral: EMBRAPA, CNPC, 1980. 32p.
- FOGARTY, N.M.; HALL, D.G.; ATKINSON, W.R. Productivity of three crossbred ewe types mated naturally at 8-monthly intervals over two years. **Australian Agricultural Research**, v.43, p.1819-1832, 1992.
- FOOTE, W.C.; SEFIDBAKHT, N.; MADSEN, M.A. Puberal estrus and ovulation and subsequent estrous cycle patterns in the ewe. **Journal of Animal Science**, v.30, p.86-90, 1970.
- FOSTER, D.L.; RYAN, K.D. Mechanism governing onset of ovarian cyclicity at puberty in the lamb. **Annales de Biologie Animale, Biochimie, Biophysique**, v.19, p.1369-1379, 1979.
- FURUSHO-GARCIA, I.F.; PEREZ, J.R.O.; BONAGURIO, S.; ASSIS, R.M.; PEDREIRA, B.C.; SOUZA, X.R. Desempenho de cordeiros Santa Inês puros e cruzas Santa Inês com Texel, Ile de France e Bergamácia. **Revista Brasileira de Zootecnia**, v.33, p.1591-1603, 2004.
- GALINA, M.A.; MORALES, R.; SILVA, E.; LÓPEZ, B. Reproductive performance of Pelibuey and Blackbelly sheep under tropical management systems in Mexico. **Small Ruminant Research**, v.22, p.31-37, 1996.
- GARCIA, C.A.; MONTEIRO, A.L.G.; COSTA, C.; NERES, M.A.; ROSA, G.J.M. Medidas objetivas e composição tecidual da carcaça de cordeiros alimentados com diferentes níveis de energia em *creep feeding*. **Revista da Sociedade Brasileira de Zootecnia**, v.32, p.1380-1390, 2003.
- GIRÃO, R.N.; MEDEIROS, L.P.; GIRÃO, E.S. **Índices produtivos de ovinos da raça Santa Inês no Estado do Piauí**. Teresina: EMBRAPA, UEPAE, 1984. 5p.
- GONZALEZ, A.; MURPHY, B.D.; FOOTE, W.C.; ORTEGA, E. Circannual estrous variations and ovulation rate in Pelibuey ewes. **Small Ruminant Research**, v.8, p.225-232, 1992.
- GONZÁLEZ-REYNA, A.; VALENCIA, J.; FOOTE, W.C.; MURPHY, B.D. Hair sheep in Mexico: Reproduction in Pelibuey sheep. **Animal Breeding Abstract**, v.59, p.509-524, 1991.
- HAFEZ, E.S.E. Studies on the breeding season and reproduction of the ewe. **Journal of Agricultural Science**, v.42, p.189-265, 1952.
- HARE, L.; BRYANT, M.J. Characteristics of oestrous cycles and plasma progesterone profiles of young female sheep during their first breeding season. **Animal Production**, v.35, p.1-7, 1982.
- HERNANDEZ, M.X.; CHESNEAU, D.; CHEMINEAU, P.; MALPAUX, B.; MIGAUD, M. Evidence for photoreponsiveness in Black-Belly sheep that are continuous breeders in the tropics. In: SYMPOSIUM OF EUROPEAN PINEAL & BIOLOGICAL RHYTHMS SOCIETY, 9., Aberdeen, 2002. **Proceedings**. Aberdeen, 2002. Abstract P-43.
- KEANE, M.G. The duration of the breeding season in Suffolk x Galway ewe lambs. **Journal of Agricultural Science**, v.85, p.569-570, 1975.
- KÖPPEN, W. **Climatologia**. Buenos Aires: Panamericana, 1948. 478p.
- MBAYAHAGA, J.; MANDIKI, S.N.M.; BISTER, J.L.; PAQUAY, R. Body weight, oestrous and ovarian activity in local Burundian ewes and goats after parturition in the dry season. **Animal Reproduction Science**, v.51, p.289-300, 1998.
- MINTON, J.E. Role of photorefractoriness in onset of anoestrous in Rambouillet X Dorset ewes. **Journal of Reproduction and Fertility**, v.89, p.261-268, 1990.
- NATIONAL RESEARCH COUNCIL. **Nutrient requirements of sheep**. 6.ed. Washington: National Academic of Sciences, 1985.
- RAVINDRA, J.P.; RAWLINGS, N.C. Ovarian follicular dynamics in ewes during the transition from anoestrus to the breeding season. **Journal of Reproduction and Fertility**, v.110, p.279-289, 1997.
- RIBEIRO, E.L.A.; ROCHA, M.A.; SILVA, L.F. Aspectos reprodutivos em ovelhas Hampshire down submetidas à monta continua na região norte do Paraná. **Revista Brasileira de Zootecnia**, v.25, p.637-646, 1996.
- ROCHA, M.H.M.; SUSIN, I.; PIRES, A.V.; FERNANDES JR., J.S.; MENDES, C.Q. Performance of Santa Inês lambs fed diets of variable crude protein levels. **Scientia Agricola**, v.61, p.141-145, 2004.
- RODA, D.S.; SANTOS, L.E. dos; CUNHA, E.A. da; BIANCHINE, D.; FEITOZA, A.S.L. Desempenho de ovinos em sistema de acasalamento a cada oito meses. **Boletim da Indústria Animal**, v.50, p.49-54, 1993.

- SASA, A.; TESTON, D.C.; SILVA, E.C.F.; CRIVELLENTI, T.L.; PÔRTO, M.S.C.S.; RODRIGUES, P.A.; COELHO, L.A. Perfil plasmático de progesterona e incidência mensal de ovulações silenciosas em borregas lanadas e deslanadas criadas no Estado de São Paulo. In: CONGRESSO BRASILEIRO DE ZOOTECNIA, 21., Goiânia, 2001. **Anais**. Goiânia, 2001. p.16.
- SASA, A.; TESTON, D.C.; CRIVELLENTI, T.L.; RODRIGUES, P.A.; SILVA, E.C.F.; COELHO, L.A.; SCHALCH, E. Concentrações plasmáticas de progesterona em borregas lanadas e deslanadas durante o período de abril a novembro no Estado de São Paulo. **Revista Brasileira de Zootecnia**, v.31, p.1150-1156, 2002.
- STATISTICAL ANALYSIS SYSTEM INSTITUTE. **User's guide**; Release 8.0 2.ed. Cary: SAS Institute, 1995. 1686p.
- SILVA, O.L.; FIGUEIRÓ, P.R.P. Efeito da época de cobertura sobre a fertilidade de ovelhas e mortalidade de cordeiros na raça Corriedale. In: REUNIÃO ANUAL DA SOCIEDADE BRASILEIRA DE ZOOTECNIA, 17., Fortaleza, 1980. **Anais**. Fortaleza: SBZ, 1980. p.127.
- SILVA SOBRINHO, A.G.; PURCHAS, R.W.; KADIM, I.T.; YAMAMOTO, S.M. Características da qualidade da carne de ovinos de diferentes genótipos e idade ao abate. **Revista Brasileira de Zootecnia**, v.34, p.1170-1078, 2005.
- SIQUEIRA, E.R.; SIMÕES, C.D.; FERNANDES, S. Efeito do sexo e do peso ao abate sobre a produção de carne de cordeiros. Morfometria da carcaça, pesos dos cortes, composição tecidual e componentes não constituintes da carcaça. **Revista Brasileira de Zootecnia**, v.30, p.1299-1307, 2001.

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