Ciências Agrárias
SEMINA

DOI: 10.5433/1679-0359.2025v46n4p1277

Characterization of maternal-filial behavior in the postpartum period of Santa Inês sheep

Caracterização do comportamento materno-filial no período pós-parto de ovelhas Santa Inês

Francisco Miguel de Melo Oliveira[1]; Dermeval de Araújo Furtado[2]; Wandrick Hauss de Sousa[3]; José Pinheiro Lopes Neto[2]; Airton Gonçalves de Oliveira[1]; Tacila Rodrigues Arruda[1]; Ricardo de Sousa Silva[1]; Luiza Lira Leite[1]; Matteo Barbari[4]; Neila Lidiany Ribeiro[5]*

Highlights

The information can be used to propose management strategies.
Behavior should be considered when choosing a genetic group for breeding.
The maternal activity is an important parameter in the selection of breeding ewes.

Abstract

The objective of this study was to characterize the maternal-filial relationship of purebred Santa Inês (SI) sheep, ½ Santa Inês x Dorper (DP) and ¾ Santa Inês x Dorper after lambing. For behavioral observations, 65 females were monitored, including 17 purebred SI sheep, 25 ½ SI x DP sheep, and 23 ¾ SI x DP sheep, analyzing the maternal-filial behavior of the sheep and lambs at 5-minute intervals over a 12-hour observation period. The weight of the lambs did not present a significant difference (P = 0.987), considering the genotypes, but there was a significant difference (P = 0.024) considering the sex of the animals. The weight of the animals presented a significant difference (P = 0.012) as a function of the genotype x sex interaction. Considering the activity of the ewes with their offspring, it is observed that no activity presented significant difference depending on the genotype that is, even with the degree of blood of a paternal breed, the maternal breed present in the crossing is important and the characteristic of maternal ability is maintained. Regarding the posture of the ewes with their young, it was observed

[1] Doctoral Students of the Postgraduate Program in Agricultural Engineering, Universidade Federal de Campina Grande, UFCG, Campina Grande, PB, Brazil. E-mail: cjcaqui@gmail.com; airtonufcg1454@gmail.com; tacila.r.arruda@gmail.com; 2822ricardo@gmail.com; luizaliraarq@gmail.com
[2] Profs., Universidade Federal de Campina Grande, UFCG, Campina Grande, PB, Brazil. E-mail: araujodermeval@gmail.com; lopesneto@gmail.com
[3] Researcher, Empresa Paraibana de Pesquisa, Extensão Rural e Regularização Fundiária, EMPAER, Joao Pessoa, PB, Brazil. E-mail: wandrick@gmail.com
[4] Prof., Università degli Studi di Firenze, Firenze, Italy. E-mail: matteo.barbari@unifi.it
[5] Postdoc, Postgraduate Degree in Agricultural Engineering, Universidade Federal de Campina Grande e da Fundação de Apoio à Pesquisa da Paraiba FAPESQ, Campina Grande, PB, Brazil. E-mail: neilalr@hotmail.com
* Author for correspondence

Received: Mar. 14, 2025 Approved: Aug. 21, 2025

that there was a significant difference according to the genotype, the pure Santa Inês ewes spent less time moving (P = 0.034). The activities of the lambs searching for the udder (P = 0.034) and trying to get up (P = 0.035) showed significant differences according to the genotype, with the values being lower in the pure Santa Inês. Newly lambed ewes spent their time mainly on behavior aimed at forming an emotional bond with their offspring, and on important care for the lamb's immediate survival, such as cleaning the newborn's body. For the lambs, once they were able to stand up and move around, they prioritized the ingestion of colostrum.
Key words: Animal behaviour. Ethology. Maternal behaviour. Peripartum. Small ruminant.

Resumo

Objetivou-se com esta pesquisa caracterizar a relação materno-filial de ovelhas de raça pura Santa Inês (SI), ½ Santa Inês x Dorper (DP) e ¾ Santa Inês x Dorper após o parto. Para observações comportamentais, foram monitoradas 65 fêmeas, incluindo 17 ovelhas de raça pura SI, 25 ovelhas ½ SI x DP e 23 ovelhas ¾ SI x DP, analisando o comportamento materno-filial das ovelhas e cordeiros em intervalos de 5 minutos durante um período de observação de 12 horas. O peso dos cordeiros não apresentou diferença significativa (P = 0,987), considerando os genótipos, mas houve diferença significativa (P = 0,024) considerando o sexo dos animais. O peso dos animais apresentou diferença significativa (P = 0,012) em função da interação genótipo x sexo. Considerando a atividade das ovelhas com seus filhotes, observa-se que nenhuma atividade apresentou diferença significativa em função do genótipo, ou seja, mesmo com o grau de sangue de uma raça paterna, a raça materna presente no cruzamento é importante e a característica da capacidade maternal é mantida. Em relação à postura das ovelhas com seus filhotes, observou-se que houve diferença significativa de acordo com o genótipo, as ovelhas Santa Inês puras passaram menos tempo se movimentando (P = 0,034). As atividades dos cordeiros procurando o úbere (P = 0,034) e tentando se levantar (P = 0,035) apresentaram diferenças significativas de acordo com o genótipo, com os valores sendo menores nas ovelhas Santa Inês puras. As ovelhas que acabaram de parir passavam a maior parte do tempo realizando comportamentos destinados a formar um vínculo emocional com seus filhotes e cuidando de aspectos importantes para a sobrevivência imediata dos cordeiros, como limpar o corpo dos recém-nascidos. Os cordeiros, por sua vez, assim que conseguiam ficar de pé e se movimentar, priorizavam a ingestão de colostro.
Palavras-chave: Comportamento animal. Etologia. Comportamento materno. Peripartum. Pequeno ruminante.

Introduction

In arid and semiarid regions, small ruminants are raised in extensive systems, using native forest as their main food source, allowing ewes and lambs to remain together from birth to weaning (Fonseca et al., 2016; Leite et al., 2021). Among the behavioral patterns that contribute to reproductive success, none is more important than maternal behavior, and is associated with the care and survival of the young, particularly in extensive conditions (Putu et al., 1988). Santa Inês sheep are known for their prolificacy, maternal ability and good adaptation to the breeding system in semiarid regions (Barros et al., 2005). They are non-seasonal polyestrous, which allows lamb production all year round.

Behavior plays an important role in the processes of adaptation through natural selection to an environment (Atkin-Willoughby et al., 2022). Knowing the ethogram of motivated behaviors, such as reproductive and parental behaviors, helps to understand the adaptation of a given population in an environment (Pritchard et al., 2021). Maternal-filial behavior is defined as anything done by parents that increases the ability of their offspring to survive and reproduce, while decreasing the ability of the parents to invest in future offspring (Trivers, 1974). In recent years, observations of animal behavior have helped not only in animal management but have also contributed to reducing stress resulting from the intense productive exploitation of flocks.

Several factors can alter the maternal-filial relationship of ewes and their lambs, such as the time of establishment of the first contact, ewe nutrition, type of calving and lambing order, the latter of which significantly influences the initial development of lambs, since primiparous ewes end up being more stressed during the initial stage of the maternal-filial relationship (Dada et al., 2021; Freitas-de-Melo et al., 2021; Porciuncula et al., 2021; Casian et al., 2024).

The high mortality rate of lambs before weaning has been a worldwide problem, remaining between 15-20% (Flinn et al., 2020), which negatively affects sheep production. The postpartum period in sheep is characterized by expressive behavioral interaction between the ewe and newborn lambs (Dwyer & Lawrence, 1998; Dwyer, 2003), with the lamb's first behaviors typically directed towards the mother, with extremely close special associations between them during the first three days of life (Morgan & Arnold, 1974). This study aimed to characterize the maternal-filial relationship of Santa Inês sheep and their crossbreds after lambing.

Material and Methods

The research procedures were approved by the Research Ethics Committee (REC) of the Federal University of Campina Grande, Paraíba State, Brazil, CEP Protocol No. 097.2019.

This experiment was conducted at the Benjamim Maranhão Experimental Station, of the State Agricultural Research Corporation of the State of Paraíba, located in the municipality of Tacima, PB, with latitude 6° 29´ 18" S, Longitude 35° 38´ 14" W and altitude of 164m. The region is characterized by a negative hydric balance which is resultant from annual average rainfall lower to 800 mm, insolation of 2800 h/year, year average temperature range from 23.0 to 28.7 °C, evaporation of 2000 mm/year and air relative humidity around 60% (Gois et al., 2017).

The gestation and births of 65 ewes were monitored, including 17 pure Santa Inês (SI) females, 25 ½ Santa Inês x Dorper (1/2 SI x DP), and 23 ¾ Santa Inês x Dorper (3/4 SI x DP), all multiparous with a body condition score between 1.5 and 3.0.

From these crosses, 98 lambs were born, which were observed until the first feeding. To facilitate the nocturnal visualization of the females in labor, a rechargeable battery-powered flashlight was used. The animals were identified by collars, earrings and tattoos, providing more efficient zootechnical control. The females

were covered by a pure Dorper sire per cross with a live weight of 45.8 kg, in a controlled breeding season, and had their body condition score and weight measured before and after the season.

This reproductive management was carried out to determine the expected date of calving of each ewe, using a gestational calendar. Thus, the females of the flock began to be observed seven days before the expected date of calving of the first ewe. The ewes were confined in a large, open area with access to fresh water and feeders; and the stalls were covered with clay tiles to provide better thermal comfort and facilitate observation. One stall was kept isolated to receive the ewes at the time of calving.

For data collection, two stages were observed: First, the characterization of the births was observed in terms of type, which refers to the number of lambs born per birth, whether single or double. Birth weights were measured after the first feeding, so as not to interfere with the behavior of ewes and lambs during the observation period.

In the second stage, the behavior, posture, and activity of the ewes and lambs were recorded according to Cansian et al. (2024). A single observer recorded the behavior and posture of ewes and lambs (instantaneous focal sampling) at 5-minute intervals, starting at the complete fetal expulsion (Mobini, Heath & Pugh, 2002).

Whenever lambs performed any activity for the first time, regardless of the sampling interval, the hours were recorded on a spreadsheet attached to the ethogram. After the lamb successfully suckled, it was weighed, the umbilicus was disinfected and cut, and an ear tag was attached. Ewes and lambs were weighed every seven days, and continuing until weaning.

Normality was checked by examining the asymmetry and kurtosis coefficients. All non-significant terms were removed and the models fitted again. Days after birth and type of birth were defined as fixed effects in the final model.

Birth weight was analyzed considering a 3x2 factorial, with blood type (STI, 1/2 STI and 3/4 STI) and sex (male and female) and compared using the Student's test from PROC GLM in SAS on demand (2024).

The negative binomial distribution (data measured as frequency) was used. The maternal and offspring behavior variables were observed using PROC FREQ from SAS on demand (2024), considering the effect of blood type (STI, 1/2STI and 3/4 STI).

Results

The weight of the lambs did not present a significant difference (P = 0.987), considering the genotypes, but there was a significant difference (P = 0.024) considering the sex of the animals (Table 1). The weight of the animals presented a significant difference (P = 0.012) as a function of the genotype x sex interaction. Males and females with 3/4 Santa Inês Dorper blood presented higher birth weight than the other genotypes, with the lowest birth weight value for lambs from pure Santa Inês ewes (Table 1). It was observed that with the inclusion of Dorper blood, comparing pure Santa Inês with animals with 3/4 SI x Dorper blood, there was an increase in the weight of the female and male of 28% (0.97 kg) and 26% (1.03 kg), respectively.

Table 1
Mean and standard deviation of birth weight of lambs according to genotype and sex

Genotype	Sex	
	Female	Male
Santa Inês	2.38±0.29bC	2.92±0.30aC
½ Santa Inês x Dorper	3.03±0.10bB	3.36±0.32aB
¾ Santa Inês x Dorper	3.35±0.15bA	3.95±0.33aA
	P-value	
Genotype	0.987	
Sex	0.024	
Genotype x Sex	0.012	

Means followed by the same lowercase letter in the column and uppercase letter in the row do not differ statistically from each other using the Student test at the 5% probability level.

Considering the activity of the ewes with their offspring, it is observed that no activity presented significant difference depending on the genotype (Table 2), that is, even with the degree of blood of a paternal breed, the maternal breed present in the crossing is important and the characteristic of maternal ability is maintained.

Table 2
Activities of ewes with their offspring after lambing

Activities (%)	Santa Inês	½ Santa Inês x Dorper	¾ Santa Inês x Dorper	*P-value*
Cleaning the lamb	48.83	48.68	48.71	0.098
Other activities	23.64	23.94	23.78	0.876
No apparent activity	8.52	8.68	8.59	0.056
Ingesting membrane	7.36	7.63	7.73	0.786
Making breastfeeding easier	2.71	2.63	2.86	0.245
Stimulating the offspring	2.32	2.10	2.29	0.345
Smelling or touching the young	2.32	2.10	2.00	0.345
Make breastfeeding difficult	1.93	2.10	2.00	0.645
Move away from the young	1.93	1.84	1.71	0.054
Attacking the young	0.44	0.30	0.33	0.876

Regarding the posture of the ewes with their young (Table 3), it was observed that there was a significant difference according to the genotype, the pure Santa Inês ewes spent less time moving (P = 0.034), which facilitates the suckling of the young, and numerically they spent more time standing and less time lying down.

Table 3
Laying of ewes with their offspring

Activites (%)	Santa Inês	½ Santa Inês x Dorper	¾ Santa Inês x Dorper	*P-value*
Standing	90.51	90.26	89.96	0.534
Lying down	5.45	5.52	5.79	0.623
On the move	4.04	4.22	4.25	0.034

The activities of the lambs searching for the udder (P = 0.034) and trying to get up (P = 0.035) showed significant differences according to the genotype, with the values being lower in the pure Santa Inês. A representative portion of the lambs' time (12.15, 12.12 and 12.20%, respectively) was spent performing other activities, represented mainly by vocalizations directed at the mothers and exploratory activities of the environment (Table 4). Regarding the posture of the lambs, there was no significant difference considering the genotype (Table 5).

Table 4
Activities of lambs born from the pure, ½ blood and ¾ blood Santa Inês (STI)

Activites (%)	Santa Inês	½ Santa Inês x Dorper	¾ Santa Inês x Dorper	*P-value*
No apparent activity	41.31	41.50	41.29	0.076
Trying to breastfeed	15.27	15.36	15.32	0.064
Looking for udder	13.88	14.01	14.02	0.034
Other activities	12.15	12.12	12.20	0.098
Trying to get up	9.67	9.97	10.06	0.035
Sucking	5.90	5.66	5.71	0.646
Getting up	1.38	1.43	1.59	0.064

Table 5
Laying of lambs born from the pure, ½ blood and ¾ blood Santa Inês (STI) genotypes

Activites (%)	Santa Inês	½ Santa Inês x Dorper	¾ Santa Inês x Dorper	*P-value*
Standing	47.09 (138)	47.73 (179)	47.66 (184)	0.645
Lying down	46.75 (137)	46.13 (173)	46.11 (178)	0.078
On the move	6.16 (18)	6.14 (23)	6.23 (24)	0.065

Discussion

The difference between birth weight of males and females occurs mainly due to differences in sex chromosomes, probably in the position of genes related to growth, due to differences in the endocrine system, especially in sex hormones (Szadàvi et al., 2023). Between 30 and 90 days of age, male lambs have an average daily weight gain of 300 g, and females of 275 g. At 70 days of age, well-formed males reach 27 kg and females 23 kg (Empresa Brasileira de Pesquisa Agropecuária [EMBRAPA], 2021). The maternal ability of sheep with a calmer temperament is associated with the survival of their offspring. The development of the lamb is connected to the behavior of the mother, which can directly affect the weight of the lamb at weaning, and the productivity of the ewe itself (Karaka et al., 2023).

The ¾ SI x Dorper animals had greater weight, demonstrating that the crossbred animals externalized the maternal ability and rusticity of the Santa Inês breed, demonstrating that gene transfer, that is, genetic inheritance, is present when different breeds are crossed.

Early maternal care impacts the time it takes lambs to attempt and succeed in standing, reaching for the udder, and suckling for the first time, which is shorter than among those whose mothers spend more time cleaning and smelling their offspring, i.e., the longer the ewes take to clean their offspring, the longer it takes the lambs to suckle for the first time. Typically, ewes lick their lambs until they are ready to stand, demonstrating maternal care. In the first seconds after giving birth, the ewe stands up and begins to smell and lick the lamb, starting with the head and neck, and remains close to the lamb to ingest colostrum (Karaka et al., 2023).

According to Arnold and Morgan (1975), shortly after giving birth, the ewe begins to clean the lamb by ingesting the placental membranes and fetal fluids, and then the lamb tries to stand up, which can take between 10 and 180 min. This behavior of the ewe towards the offspring stimulates the lamb's breathing and triggers a series of important physiological events, so that the newborn can suckle for the first time and receive passive immunity.

Maternal recognition of a ewe with her offspring begins a few hours before birth and continues until the moment she recognizes her offspring. This recognition in sheep occurs between 20 to 30 minutes after birth. When the ewe allows the lamb to take the first suckling, ingesting colostrum, it means that she has recognized and accepted it as

her own. (Lynch et al., 1992). The mother's contact with her offspring is essential for them to recognize each other, stimulates the lamb's behavior (mainly the search for the udder), and breathing, and controls the newborn's thermoregulation (Nowak et al., 2021). This direct contact reduces the lamb mortality rate, which is a major concern in sheep farming, as it can increase production costs and harm productive activity (Flinn et al., 2020). The results regarding the average time until the first suckle coincide with those found by Porciuncula et al. (2021) in a study with Pantanal sheep.

The time spent between birth and the first feeding, as well as cleaning the lamb, are the two behaviors most related to the creation of the bond between the mother and the newborn, as sheep use olfactory and auditory cues for maternal-filial recognition. Cleaning the newborn's body is essential for olfactory recognition between the mother and calf, to stimulate breathing, the search for the udder, thermoregulation and to dry the lamb, in order to reduce the risk of hypothermia (Dwyer & Lawrence, 2005; Porciuncula et al., 2021).

The ingestion of embryonic appendages (placentophagy) minimizes the risk of predators, by removing olfactory clues to the birth site. In primiparous ewes, the absence of fetal fluids in the newborn can lead to failure to clean its body, refusal to accept the lamb, and aggressive behavior (Nowak et al., 2000). The maternal ability of Santa Inês females in relation to their crossbreeds it demonstrated through antagonistic behavior towards the neonate, such as hindering suckling, moving away from the offspring and aggression, since this native breed has as its primary goal the survival of the offspring and the maintenance of the species. Some cases of aggression that occurred were related to ewes that adopted lambs from other mothers during prepartum, and did not recognize their offspring after birth. The same was observed in some cases of females that gave birth to twins, but rejected the second neonate (Blackshaw, 2003).

The low incidence of displacement reflects the formation of the bond between the mother and the lamb at the birth site, and during this period, social contact tends to be limited to this particular relationship, an important preliminary step for the formation of the maternal-child bond. Thus, these actions protect the mother-cub pair from disturbances by congeners and predators, facilitating initial interactions. This behavior is inversely related to the abandonment of lambs and the mortality of the newborn resulting from separation from its mother (May et al., 2007).

The movement of ewes was sometimes associated with the activity of “moving away from the lamb”. However, it also occurred in cases of lambs moving away from their mothers, and the mothers followed them to avoid separation. This was particularly observed in the case of ewes caring for twins, and all lambs explored the environment in one direction (Nowak, Porter & Levy, 2000). The establishment of a maternal-filial bond in the first hours after birth is one of the essential characteristics of maternal behavior in ungulates. The establishment and sedimentation of this behavior depends on the hormonal scenario and its synchronization with birth, to ensure that the ewe meets the needs of the lamb. This synchronization is the result of physiological and sensory changes in the

ewe that culminate in maternal care, which is important for psychological development (Lévy et al., 2009).

The standing posture and low incidence of movement by the ewes are related to the mother's cooperation with the lamb's attempts to suckle, and have a large influence on the time required for this first suckle. The lamb is unlikely to be successful if its mother remains lying down for a long period or moves around or away from it (Blackshaw, 2003).

Regarding the lamb's behavior, it recognizes its mother through visual contact, and this relationship develops in the first week of life. In most species, the young emit certain signals (olfactory, acoustic and visual) that trigger care reactions. The removal of fluids by the mother, minutes after birth, can help reduce heat loss and stimulate the lamb's search for the teat, through exploratory movements on the mother's body (touch), resulting in the location of the udder, by detecting characteristic odors produced by the inguinal glands and the placental remains attached to the ewe (Dwyer, 2014).

The high incidence of vocalizations is also related to genetic factors, and breeds that are less selected by humans and more adapted to extensive conditions tend to vocalize more intensively than other genotypes. The Santa Inês breed may fit into these conditions. Animals raised free range tend to vocalize more intensively than confined or specialized animals (Dwyer & Lawrence, 2005). Vocalization is a desirable characteristic, since, based on this behavior, lambs will establish recognition between individuals. Dwyer & Lawrence (1998) state that ewes have a specific vocalization during childbirth, characterized by a low-pitched bleat or "snort" made to the lamb to establish the maternal-filial connection. Nowak et al. (2021) and Sèbe et al. (2010) highlight the importance of ewes distinguishing their lambs and, of the vocalizations of the mother and offspring during postpartum care to establish the maternal-filial relationship.

The presence of the mother has a calming effect on her offspring, and separation can produce anxiety reactions in both the mother and the offspring, this behavior is observed through vocalizations, one of the ways in which sheep express their behavior. Sheep generally vocalize in three situations: separation from the flock, ewe-lamb communication, and ram-ewe communication during mating. Vocalizations in large quantities and of low intensity are emitted at the time of birth, helping to guide the offspring to the mother and providing signals for its later recognition (Lynch et al., 1992).

Newborns that stand up more quickly tend to ingest colostrum more quickly as well, suggesting that lambs that nurse earlier tend to spend more time standing. This increased standing time allows the animal to nurse more quickly, and has less contact with the floor of the birthplace, which can be a source of contamination, and stimulates the cub' balance.

Conclusions

Newly lambed ewes spent their time mainly on behavior aimed at forming an emotional bond with their offspring, and on important care for the lamb's immediate survival, such as cleaning the newborn's

body. For the lambs, once they were able to stand up and move around, they prioritized the ingestion of colostrum.

The information from this study can be used to propose management strategies to improve production rates, such as lower lamb mortality and higher weight in the first two weeks postpartum, a critical period for lamb survival. It is important to highlight that behavioral aspects should be taken into consideration when choosing a genetic group for breeding, and, that locally adapted animals will probably have advantages over exotic breeds not adapted to the chosen breeding location. The maternal activity of Santa Inês ewes can become an important parameter to aid in the future selection of breeding ewes that will remain in the flock.

References

Arnold, G. W., & Morgan, P. D. (1975). Behavior of ewe and lamb t lambing and its relationship to lamb mortality. *Applied Animal Ethology, 2*(1), 25-46. doi: 10.10 160304-3762(75)90063-2

Atkin-Willoughby, J., Hollick, S., Pritchard, C. E., Williams, A. P., Davies, P. L., Jones, D., & Smith, A. (2022). Microclimate drives Shelter-seeking behaviour in lambing ewes. *Forests, 13*(12), 1-19. doi: 10.3390/f13122133

Barros, N. M., Vasconcelos, V. R., Araújo, M. R. A., & Martins, E. C. (2005). Influence of genetic group and feeding on the performance of lambs in confinement. *Brazilian Agricultural Research, 38*(6), 1111-1116. doi: 10.1590/S0100-204X2003000900013

Blackshaw, J. K. (2003). *Notes some topics in applied animal behavior.* University of Queensland.

Cansian, K., Longo, M. L., Silva, A. L. A., Souza, M. R., Costa, C. M., Silva, E. V. C., Santos, A. R. D., & Vargas, F. M., Jr. (2024). Exploratory study of the maternal-filial relationship among sheep: factors that impact the performance of lambs in a locally adapted Pantaneiro flock. *Acta Agriculturae Scandinavica, Section A-Animal Science, 73*(3-4), 165-171.

Dada, J. M. V., Ribeiro, L. N., Oliveira, A. N., Silva, J. R., & Gottardi, F. P. (2021). Comportamento materno e produtivo de cordeiro Santa Ines. *Enciclopédia Biosfera, 18*(38), 123-131.

Dwyer, C. M. (2003). Behavioural development in the neonatal lamb: effect of maternal and birth-related factors. *Theriogenology, 59*(3-4), 1027-1050. doi: 10.1016/S0093-691X(02)01137-8

Dwyer, C. M. (2014). Maternal behavior and lamb survival: from neuroendocrinology to practical application. *Animal, 8*(1), 102-112. doi: 10.1017/S1751731113001614

Dwyer, C. M., & Lawrence, A. B. (1998). Variability in the expression of maternal behaviour in primiparous sheep: effects of genotype and litter size. *Applied Animal Behaviour Science, 59*(3-4), 311-330. doi: 10.1016/S0168-1591(97)00148-2

Dwyer, C. M., & Lawrence, A. B. (2005). A review of the behavioral and physiological adaptations of extensively managed breeds of sheep that favor lamb survival. *Applied Animal Behaviour Science, 92*(3), 235-260. doi: 10.1016/j.applanim.2005.05.010

Empresa Brasileira de Pesquisa Agropecuária. Embrapa Caprinos e Ovinos (2021). *Recomendações de dietas para ovinos que conferem resiliência à verminose.* (Boletim de Pesquisa e Desenvolvimento, 18). Embrapa Caprinos e Ovinos.

Flinn, T., Kleeman, D. O., Swinbourne, A. M., Kelly, J. M., & Weaver, A. C. (2020). Neonatal lamb mortality: major risk factors and the potential ameliorative role of melatonin. *Journal of Animal Science and Biotechnology, 11*(1), 1-11. doi: 10.1186/s40104-020-00510-w

Fonseca, V. F. C., Saraiva, E. P., Arruda, M. F., Pereira, W. E., Pimenta, E. C., Fº., Santos, S. G. C. G., Amorim, M. L. C. M., & Silva, J. A. (2016). Mother-offspring relationship in Morada Nova sheep bred in a tropical semiarid environment: a perspective on maternal investment and parental conflict. *Applied Animal Behaviour Science, 183*, 51-58. doi: 10.1016/j.applanim.2016.07.002

Freitas-de-Melo, A., Pérez-Clariget, R., Terrazas, A., & Ungerfeld, R. (2021). Ewe lamb bond of experienced and inexperienced mothers undernourished during gestation. *Scientific Reports, 11*, Article 84334. doi: 10.1038/s41598-021-84334-2

Gois, G., Silva, F. M. da, & Santos, J. M. dos. (2017). Dinâmica temporal dos parâmetros climatológicos e balanço hídrico no manejo de culturas agrícolas. *Engenharia Agrícola, 38*(5), 705-717. doi: 10.1590/1809-4430-Eng.Agric.v38n5p705-717/2018

Karaka, S., Aydogdu, N., & Ser, G. (2023). Effect of maternal experience and body condition on patterns of ewe-lamb bonding behaviors and pre-weaning growth performance of lambs. *Journal of Veterinary Behavior, 67*, 1-7. doi: 10.1016/j.jveb.2023.07.003

Leite, J. H. G. M., Façanha, D. A. E., Bermejo, J. V. D., Guilhermino, M. M., & Bermejo, L. A. (2021). Adaptive assessment of small ruminants in arid and semi-arid regions. *Small Ruminants Research, 20*, 106497. doi:10.1016/j.smallrumres.2021.106497

Lévy, F., Keller, M., & Poidron, P. (2009). Olfactory regulation of maternal behavior in mammals. *Hormones and Behaviour, 46*(3), 284-302. doi: 10.1016/j.yhbeh.2004.02.005

Lynch, J., Hinch, G., & Adams, D. B. (1992). *The behavior of sheep: biological principles and implications for production.* CAB International.

May, R., Vandyke, J., Forland, J. M., Andersen, R., & Landa, A. (2007). Behavioral patterns in ewe-lamb pairs and vulnerability to predation by wolverines. *Applied Animal Behaviour Science, 112*(1-2), 58-67. doi: 10.1016/j.applanim.2007.07.009

Mobini, S., Heath, A.M., & Pugh, D. (2002). Theriogenology of sheep and goats. In D. G. Pugh (Ed.), *Sheep and goat medicine* (pp. 129-186). São Paulo. doi: 10.1016/B0-72-169052-1/50008-9

Mohammadi, K., Beygi Nassiri, M. T., Fayazi, J., & Roshanfekr, H. (2010). Investigation of environmental factors influence on pre-weaning growth traits in Zandi lambs. *Journal of Animal and Veterinary Advances, 9*, 1011-1014. doi: 10.3923/javaa.2010.1011.1014

Morgan, P. D., & Arnold, G. W. (1974). Behavioural relationships between Merino ewes and lambs during the four weeks after birth. *Animal Production Science, 19*(2), 169-176. doi: 10.1017/S000335610002273X

Nowak, R., Lévy, F., Chaillou, E., Cornilleau, F., Cognié, J., Marnet, P. G., Williams, P. D., & Keller, M. (2021). Neonatal suckling, oxytocin, and early infant attachment to the mother. *Frontiers in Endocrinology, 8*(11), 1-16. doi: 10.3389/fendo.2020.612651

Nowak, R., Porter, R. H., Lévy, F., Orgeur, P., & Shal, B. (2000). Role, mother-young interactions in the survival of offspring in domestic mammals. *Reviews of Reproduction, 5*(3), 153-163. doi: 10.1530/ror.0.0050153

Pettigreew, E. J., Hickson, R. E., Morris, S. T., Lopez-Villalobos, N., Pain, S. J., & Kenyon, P. R. (2019). The effects of birth rank (single or twin) and dam age on the lifetime productive performance of female dual purpose sheep (Ovis aries) offspring in New Zealand. *PLoS One, 14*, 30-43. doi: 10.1371/journal.pone.0214021

Porciuncula, G. C., Costa, J. A. A., Catto, J. B., Reis, F. A., & Fischer, V. (2021). Behavior of Pantaneiro ewes and their offspring. *Journal of Veterinary Behaviour, 44*, 40-49. doi: 10.1016/j.jveb.2021.05.006

Pritchard, C. E., Williams, A. P., Davies, P., Jones, D., & Smith, A. R. (2021). Spatial behaviour of sheep during the neonatal period: preliminary study on the influence of shelter. *Animal, 15*(7), 1-8. doi: 10.1016/j.animal.2021.10025

Putu, I. G., Poindron, P., & Lindsay, D. R. (1988). A high level of nutrition during late pregnancy improves subsequent maternal behaviour of merino ewes. *Proceedings Australian Society Animal Production, 17*, 294-297.

Nowak, R., Porter, R. H., & Lévy, F. (2000). Maternal behavior in sheep and its importance for neonatal survival. *Acta Paediatrica, 89*(s429), 22-25. doi: 10.1111/j.1651-2227.2000.tb01206.x

SAS Institute Inc. (2024). *SAS/STAT® 15.2 User's Guide: The GLM Procedure.* Cary, NC: SAS Institute Inc. Retrieved from SAS Help Center.

Sèbe, F., Duboscq, J., Aubin, T., Ligout, S., & Poindron, P. (2010). Early vocal recognition of mother by lambs: contribution of low and high-frequency vocalizations. *Animal Behaviour, 79*(5), 1055-1066. doi: 10.1016/j.anbehav.2010.01.021

Szadàvi, I., Ostatníková, D., & Durdiaková, J. B. (2023). Sex differences matter: males and females are equal but not the same. *Physiology & Behavior, 259*(1), 114038. doi: 10.1016/j.physbeh.2022.114038

Trivers, R. L. (1974). Parent-offspring conflict. *Animal Zoology, 14*(1), 249-264. doi: 10.1093/icb/14.1.249