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Udder skin temperature is related to the ewes' and lambs' behaviors at birth in autumn lambing ewes

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The survival of lambs depends on various factors, including the behavioral traits of both mother and newborn lambs at birth, as well as the ewe's colostrum production and quality. Colostrum consumption is essential for establishing the ewe-lamb bond and for increasing the lambs' survival rate. The lambs' survival rate is also related to the ewe's udder and teat morphological characteristics. The aim of this study was to determine whether udder and teat characteristics before lambing are associated with the ewe-lamb behaviors at birth and during a separation-reunion test performed 24–36 h later. The udder's volume and the length, width, and angle of the teats, and the udders' skin surface temperatures were measured on ewes before lambing. At lambing, the duration of the second stage of parturition, the latency of the ewe to lick the lamb for the first time and its duration, and the latency of the lamb to suckle for the first time and the suckle duration were recorded. Twenty-four to 36 h postpartum, a separation-reunion test was performed during which the ewe's and lamb's vocalizations, the ewe-lamb distance, and the latency to reunite and suckle were recorded. Data were collected on 50 ewe-lamb dyads during an out-of-season lambing period (autumn). Spearman correlations were conducted between udder and teat characteristics and the behaviors of ewes and lambs after birth. The udder surface skin temperatures of the ewes' were negatively related with the number of days before lambing (max: r=-0.57, P = 0.003, min: r= -0.50, P = 0.01), but were positively associated with the latency of the ewe to lick the lamb for the first time (min: r=0.46, P = 0.03), and the latency of the lambs to suckle for the first time (max: r=0.53, P = 0.007, min: r= 0.46, P = 0.02). In conclusion, a negative correlation was observed between the udder skin surface temperature and the time it took for the mothers to lick their lambs for the first time, as well as the time it took for the lambs to ingest colostrum for the first time. However, the morphological characteristics of the udder and teats recorded before birth were not found to be related to the behavioral development of the ewe-lamb bond.

KEYWORDS
maternal behavior, first suckling, udder morphology, udder volume, teat morphology, sheep

1 Introduction

In sheep, the presence of newborns covered by amniotic fluid is strongly attractive to periparturient ewes, promoting the interaction and the establishment of a selective bond with their offspring in a maximum period of 1 to 2 h after lambing (Poindron et al., 2007). Thereafter, ewes display a selective maternal care, nursing exclusively those lambs bonded immediately after parturition while rejecting others (Lévy and Keller, 2008). Accordingly, when the ewe-lamb bond is not well established, lambs are at increased risk of mismothering and starvation, which can lead to their death (Celi and Bush, 2010). This is especially problematic in extensive production systems, where environmental stressors, frequent maternal undernutrition, and limited human intervention increase this risk. Indeed, in those systems, neonatal mortality can reach 30% (Dwyer, 2008; Montossi et al., 2013), with most deaths occurring due to starvation and mismothering (Hinch and Brien, 2013). This fact is counterintuitive, as raising one's own progeny is a central force in evolution, and maternal investment is often adjusted based on the likelihood that offspring will survive to maturity (Wilson et al., 2009). Ewes' investment after lambing includes allocating resources to display maternal behavior such as licking, nursing, protecting from predators and environmental changes, and guiding the lambs to develop normal behaviors (Dwyer, 2008; Dwyer et al., 2016). It also involves producing sufficient quantities of high-quality colostrum and milk (Dwyer, 2008).

Immediately after birth, ewes lick the lamb and emit low bleats, stimulating the young to stand up and access the udder to ingest colostrum (Dwyer et al., 2016). The resources available to the ewe at parturition and to the lamb immediately after birth are determinants of the effectiveness of the lamb's access to the udder and colostrum/milk consumption. Newborn lambs are guided by sensory cues from the mother, such as touch, warmth, and scent, to find the teat and ingest colostrum (Nowak et al., 2008). The application of tactile stimulation to the face, forehead, and eyes of the newborn lambs results in elevated oral activity (Vince, 1993). Unsuckled lambs exhibit increased searching and mouthing behaviors toward warm surfaces (36-40°C), similar to the udder temperature, compared to cooler surfaces (20-32°C) (Vince, 1993). This finding suggests that udder temperature may serve as a critical cue facilitating lambs' initial access to their mother's udder. Lambs are also attracted to the udder by wax odor (Alary et al., 2025a, Alary et al., 2025b), but this attraction apparently ends shortly after accessing colostrum for the first time (Vince and Ward, 1984).

In general, successful suckling in single lambs begins with udder stimulation followed by switching to the opposite teat (Horrell et al., 1987). Nevertheless, lambs exhibit considerable individual variation in suckling behavior from early life: approximately one-third initiate sucking without butting, and the number of successful bouts per lamb varies widely (Horrell et al., 1987). This substantial inter-individual variation suggests that udder and teat morphology influence suckling success in single lambs. In pigs, a precocial species such as sheep, the udder morphology is related to young suckling behavior and teat access (Balzani et al., 2016). In sheep, colostrum consumption is essential for establishing the ewe-lamb bond (Goursaud and Nowak, 1999; Val-Laillet et al., 2006) and for increasing the lamb's survival rate (Nowak, 1996; Farooq et al., 2024). The active nursing behavior of the ewe and the ability of the lamb to access the udder have a relevant impact on the lambs' development. In fact, udder and teat scores that consider morphological characteristics are related to the lambs' growth and the survival until weaning (Griffiths et al., 2019a; Griffiths et al., 2019b). To the best of our knowledge, however, there are no studies relating the udder's and teat's main characteristics to the mother-young behaviors in sheep. We hypothesized that the main morphological characteristics of the udder and teats (size and shape) and the udder skin surface temperature are related to mother-young behaviors evaluated immediately after birth and in a separation-reunion test performed 24 to 36 h after birth. Therefore, the aim of this study was to determine whether udder and teat characteristics before lambing are associated with the ewe-lamb behaviors at birth and during a separation-reunion test performed 24–36 h later.

2 Materials and methods

The Comisión de Ética approved all the procedures en el Uso de Animales (CEUA). Facultad de Agronomía (UdelaR. Uruguay) (number 021130-001782-18).

2.1 Location and animal management

The experiment was performed at the Estación Experimental Bernardo Rosengurtt, Facultad de Agronomía, Universidad de la República (Cerro Largo, Uruguay; 32°21′S 54°26′W; humid subtropical weather, Cfa), using 50 multiparous single lambing Corriedale ewes and their lambs. Ewes were induced to ovulate and come into estrus in October (spring in the Southern Hemisphere) using the ram effect (Ungerfeld et al., 2003, Ungerfeld et al., 2005). Before mating, all ewes received antiparasitic treatment and underwent a general health assessment, including palpation of the mammary gland to detect any palpable udder defects. No ewe presented supernumerary or blind teats, nor signs of inflammation or lesions, nor the presence of lumps or diffuse hardness in one or both halves of the udder. Thus, ewes lambed during their natural breeding season (autumn), along 6 days in March (n=27) and 6 days in April (n=23). The daily average environmental temperature ranged from 20.5°C to 30.5°C (mean ± SD: 24.0 ± 1.0°C). Pregnancy and number of fetuses were determined on day 30 of gestation using a portable ultrasound equipment (Sonoscape S6, Shenzhen, China) with a 7.5 MHz linear rectal transducer, and only ewes carrying a single fetus were included in the study. The ewes remained grazing on natural grassland under extensive conditions and had free access to water from conception until 25 days before the expected date of lambing. At this date, ewes were shorn, then moved to another outdoor paddock where they grazed forage sorghum until the end of the study. Five days before the expected lambing, the ewes weighed 49.4

± 7.8 kg and had a body condition score of 3.4 ± 0.5 (BCS, scale 1–5, where 1 = emaciated and 5 = obese; Russel et al., 1969). At this moment, ewes were moved to another outdoor paddock (40 m × 45 m), where three trained observers continuously monitored lambing. In this paddock, pregnant ewes grazed natural grassland and were supplemented with 200 g. animal^{-1}. day^{-1} rice bran (88% dry matter; 14% crude protein; 9% acid detergent fiber; 24% neutral detergent fiber) in collective feeders.

2.2 Udder and teat morphological traits and udder skin surface temperatures

Five days before the expected lambing date, udder and teat characteristics were recorded in all the ewes in a standing position. At this time, no palpable defects or signs of inflammation were observed in the udder or teats. The udder circumference ($\mathcal{C}$, Figure 1A) was measured near the belly to calculate the radius (R). The length of the udder (L) was measured from the insertion of the udder to the inferior extremity (Figure 1A). The udder volume was calculated assuming that the udder was a semi-sphere, as $V = \frac{2}{3}\pi R^2 L$, according to Menant et al. (2022). The length and width of both teats were measured only on the ewes that lambed in April. Circumferences, length, and width of the udder and teats were measured by the same person using a measuring tape. Photos of the back view of the udders and the teats were used to measure the teats' angle from the median udder line. Angle degree (α) was obtained by drawing the udder (u) and teats (t) median lines, and extracting their degree of rotation displayed on the PowerPoint drawing tool, then subtracting the degree of rotation of t from that of u (Figure 1B, adapted from Rovai et al., 2004). Since angles could not be measured in all photos due to the ewes' legs covering the teats, data were collected from 46 out of 50 ewes.

The maximum and minimum temperatures of the udder skin surface were measured using an infrared thermal camera [laser class 2, 0.05–40 m ± 1% of measured distance, infrared resolution photos: 464 × 348 pixels, object range temperature: 20 to +120°C, accuracy: ± 0.3°C, field of view: 24° × 18° (18 mm lens), FLIR E95, Estonia]. The camera was calibrated to environmental, reflective temperatures, atmospheric relative humidity, and the emissivity was set to 0.98, as previously described for udders in ewes (Castro-Costa et al., 2014). To avoid heat transfer during handling, thermal images were taken before measuring the udder. A single operator took all the photos from the same distance from the udder (1.0 m). The images were analyzed using the FLIR Tools software. A circular area was delineated on each side of the udder, avoiding wool and

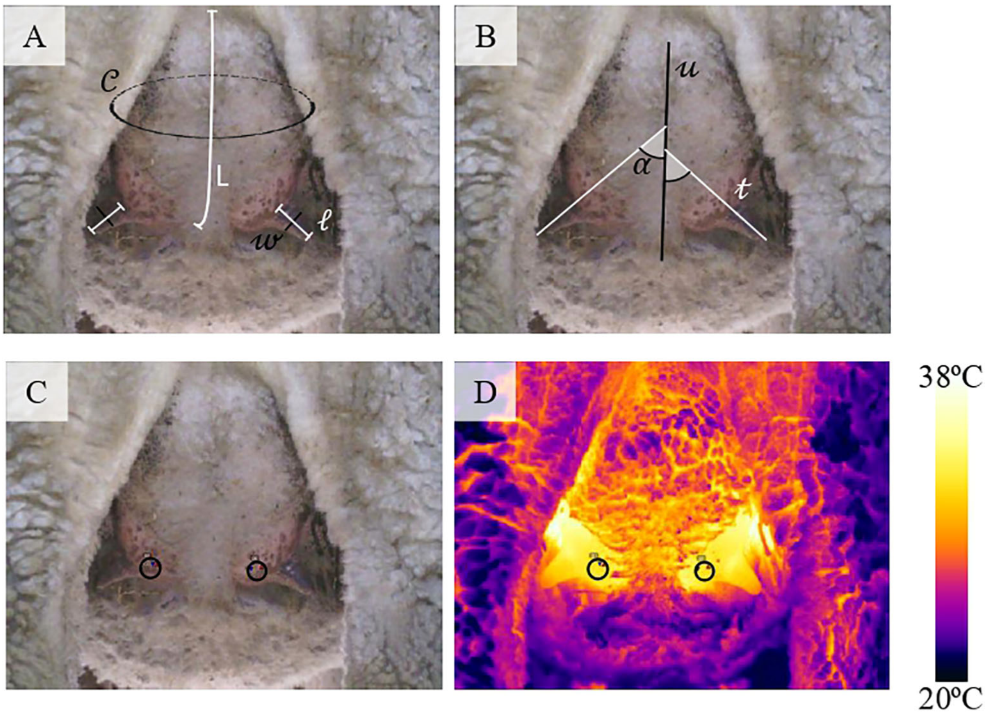

FIGURE 1
Illustration of the morphological **(A, B)** and thermal **(C, D)** measurements of the back view of Corriedale ewes' udder and teats recorded five days before the expected lambing date. **(A)**: The circumference ($\mathcal{C}$) and the length (L) of the udder, and the width (w) and length (ℓ) of the teats were measured by the same person using a measuring tape. **(B)**: Teat angles (α, light grey areas) were measured after drawing on photos the udder (u) and the teat (t) median lines. **(C, D)** Circles delineated udder areas, excluding teats and wool. In each area: **(C)** the maximum (red triangles) and minimum (blue triangles) skin surface temperatures of the ewes' udder, and **(D)** the infrared thermogram, are shown using the FLIR Tool software.

teats. For each region, the software calculated the maximum and minimum temperatures, which were then used for analysis (Figures 1C, D). Due to the wool coverage, the udder temperature was not measured in one ewe. Climate conditions, which were obtained from the nearest Weather Station (located at 32°37′ S and 54°19′ W) of the Instituto Uruguayo de Meteorología (INUMET) using a Weather Research and Forecast (WRF), were 20.8°C, 83% humidity, and 6 m.s-1 wind. The weather was recorded with automatic equipment that measured the ambient temperature under a meteorological shelter, 1.50 m above the ground.

2.3 Ewes and lambs' behavioral recording at birth and during the early postpartum period

Births, which occurred between zero and five days before the expected lambing date (2.4 ± 0.2 days; mean ± SEM), were continuously recorded during the daylight hours (sunrise: 06:30 am, to twilight: 06:30 pm). Ewe and lamb behaviors were directly observed and recorded on paper forms by three trained observers from a minimum distance of 5 m, which was sufficient to avoid disturbing the animals' normal behavior. During the sunlight hours, the behaviors at birth were recorded in 26 ewes and their lambs, according to Menant et al. (2020). The length of the second stage of parturition (from the first appearance of the fetal forelimbs until complete lamb expulsion), the latency of the ewe to lick the lamb for the first time, and the duration of that lick were recorded in min or sec, respectively. The latency of the lamb to suckle for the first time from its birth and from its first time standing, and the duration of the first suckling were also registered.

No human assistance was required at lambing, so normal behaviors were not affected. Approximately 1 hour after the first suckling (the time period needed to avoid disturbing the establishment of the ewe-lamb bond), lambs were identified with a necklace and returned with their mother to an outdoor paddock (45 m × 80 m).

A separation-reunion test was performed between 24 and 36 h after birth (from 9:00 am to 1:00 pm or from 5:30 pm to 7:00 pm) in the 50 ewe-lamb dyads, including the 26 from which recordings were done at birth. The test was performed according to Menant et al. (2020). All the dyads tested each day were first moved, in groups of 5–10 ewes and their lambs, to an open paddock (6 m × 15 m), where they remained undisturbed for at least 15 min before the first test began. At the beginning of the test, the lamb was gently lifted to separate it from its mother and subsequently restrained on the ground for 3 min by a familiar caregiver. During this period, the number of vocalizations of the ewe and of the lamb were recorded. At the end of this period and immediately before releasing the lamb, the distance of the mother from its lamb was measured using a laser distance meter (Glm 250 Vf Bosch, Switzerland). During the following 3 min, the latency to suckle the mother was also recorded. If the lamb did not suckle its mother until the end of this period, this latency was considered to be 3 min. Finally, lambs were weighed with a 1-g precision scale (4.8 ± 0.9 kg; mean ± SD) and their sex was recorded (26 males and 24 females).

2.4 Statistical analyses

All statistical analyses were performed using RStudio v1.1.463 (RStudio Team, Boston, MA) (RStudio Team, 2016). The normality of all variables was checked using the Shapiro-Wilk test. The skin surface temperatures did not differ between ewes that lambed in March or April, so data were considered as a single group. The skin surface temperatures and the teat angles, lengths, and widths did not differ between the left and right udders, so the mean values were used for the statistical analyses. Spearman correlations were conducted between udder and teats characteristics (volume, maximum and minimum skin surface temperature, teat length, width, and angle) and the ewes' and lambs' behaviors at birth, and ewe-lambs' behaviors during the separation-reunion test. Spearman correlations were also performed between the number of days between the udder measurements and the lambing date, and the maximum and minimum udder skin temperatures of the udder; and lastly, between the udder skin temperatures and the udder volume.

3 Results

3.1 Descriptive data of the ewes' udder and teats characteristics, and the ewes and lambs' behaviors

The ewes' data of the udders and teats recorded between 0 and 5 days before the day of lambing are shown in Table 1. Lambs' behaviors recorded at birth, and the lambs' and ewes' behaviors recorded during the separation-reunion test are shown in Table 2.

3.2 Relationships between ewes' udder skin surface temperatures, the time before lambing, and the udder volume

The minimum (r=-0.50, P = 0.01) and maximum (r=-0.57, P = 0.003) skin temperatures of the udder were negatively related to the

TABLE 1 Descriptive statistics (Mean ± SD and range) of the udder and teats characteristics in autumn-lambing Corriedale ewes.

Udder and teats characteristics	n	Mean ± SD	Range
Ewes' udder volume (cm^3)	50	1311.7 ± 422.9	653.7 - 2567.7
Udder's maximum skin surface temperature (°C)	49	34.8 ± 0.7	33.2 - 36.0
Udder's minimum skin surface temperature (°C)	49	32.6 ± 2.03	26.8 – 35.1
Teat's morphology			
Length (cm)	23	2.7 ± 0.6	1.5 - 4.0
Width (cm)	23	2.0 ± 0.4	1.5 - 3.0
Angle (°)	46	40.8 ± 8.9	21.8 - 59.3

Recordings were performed 5 days before the expected day of lambing.

TABLE 2 Descriptive statistics (Mean ± SD and range) of lambs' behaviors at birth (n=26) and during a separation-reunion test performed 24-36h after lambing (n=50) in autumn-lambing Corriedale ewes.

Behaviors	Mean ± SD	Range
At lambing		
The length of the second stage of parturition (min)	21.9 ± 22.5	2 - 95
Latency of the ewe to lick its lamb (s)	4.2 ± 3.7	1 - 15
First licking duration (s)	273.2 ± 295.7	2 – 1210
Latency from birth to first suckle (min)	51.9 ± 27.9	19 – 125
Latency from first time standing to first suckle (min)	24.9 ± 25.6	0 – 96
First suckle duration (s)	46.3 ± 47.6	3 – 251
Separation-reunion test		
Ewe's vocalizations	26.5 ± 16.2	0 – 87
Lamb's vocalizations	14.6 ± 11.3	0 – 46
Ewe-lamb distance (m)	3.2 ± 3.2	0.0 – 16.6
Latency to reunite (s)	11.8 ± 27.0	0 – 180
Latency to suckle (s)	94.0 ± 74.9	4.0-180

number of days from its measurement to lambing (Figures 2A, B). There were no significant correlations between the udder volume, and its maximum (r=-0.07, P = 0.73) and minimum (r=0.17, P = 0.42) skin temperatures.

3.3 Relationships between ewes' udder characteristics and ewes' and lambs' behaviors

At birth, the minimum udder surface skin temperature of the ewes was positively related to the latency of the ewe to lick its lamb for the first time (r=0.46, P = 0.03; Table 3; Figure 3A). The maximum and minimum udder surface skin temperatures of the ewes were positively related with the latency of the lambs to suckle for the first time (max: r=0.53, P = 0.007, min: r=0.46, P = 0.02; Table 3; Figures 3B, C). The maximum temperatures of the ewes' udder skin tended to be positively related to the latency of the lambs from the first time they stood up to the first suckle (r=0.37, P = 0.07; Table 3; Figure 3D). No other significant relationship was found at birth (Table 3). During the separation-reunion test, there were no significant correlations between the ewes' udder and teat characteristics and the ewes or the lambs' behaviors (Table 4).

4 Discussion

Overall, udder and teat morphological characteristics were unrelated to the lambs' and ewes' behaviors at birth, as well as to the ewe-lamb behaviors displayed during the separation-reunion test performed 24 to 36 h after birth. On the other hand, udder skin surface temperatures were the only characteristic of the udder studied related to ewes' and lambs' behavior at birth. The warmer the udder skin surface of the ewes, the longer it took for the ewes to lick their lambs for the first time, and the longer it took for lambs to suckle for the first time. Udder skin surface temperature was likely associated with udder metabolic activity and heat dissipation, but not with health problems. In this regard, mammary gland health issues, such as clinical mastitis, are infrequent in non-dairy sheep breeds (Grant et al., 2016; Cooper et al., 2016), such as those used in this study. Furthermore, no palpable defects or signs of inflammation were observed in the udder or teats during its morphology measurements. Therefore, those udders with higher surface temperatures were likely more metabolically active, causing discomfort to the ewes since they were still not nursing, thereby delaying mothers' first licks of their lambs. Maternal behavior must be synchronized with the newborn's behavior to facilitate colostrum ingestion (Poindron and Le Neindre, 1980). Mothers lick their offspring at birth to dry off the amniotic fluid, which prevents heat loss, stimulates neonatal behaviors, and assists with colostrum intake (Nowak, 2006). Therefore, if maternal behavior is affected, it could delay the initial intake of colostrum by newborn lambs.

TABLE 3 Correlation coefficients (r, Spearman tests) and P-values between the ewes' udder and teats characteristics, and the ewes' and lambs' behaviors at birth of autumn-lambing Corriedale ewes.

Udder and teats characteristics	The length of the second stage of parturition (min)		Latency of the ewe to lick its lamb (s)		Duration of the first licking (s)		Latency to suckle from birth (min)		Latency to suckle from standing up (min)		Duration of the first suckling (s)	
	r	P	r	P	r	P	r	P	r	P	r	P
Udder volume (cm^3)	0.03	0.89	0.17	0.45	0.06	0.78	-0.21	0.31	-0.09	0.65	-0.008	0.97
Udder's maximum skin surface temperature (°C)	-0.07	0.75	0.36	0.10	-0.08	0.70	0.53	0.007	0.37	0.07	0.07	0.73
Udder's minimum skin surface temperature (°C)	-0.06	0.78	0.46	0.03	-0.06	0.77	0.46	0.02	0.22	0.28	0.05	0.82
Teat length (cm)	-0.23	0.48	0.26	0.49	0.12	0.71	0.01	0.97	0.21	0.51	-0.13	0.69
Teat width (cm)	-0.23	0.47	0.03	0.94	-0.11	0.73	0.13	0.70	0.15	0.65	0.21	0.51
Teat angle ($\alpha°$)	-0.01	0.95	-0.19	0.42	-0.18	0.39	0.14	0.50	-0.06	0.77	-0.14	0.52

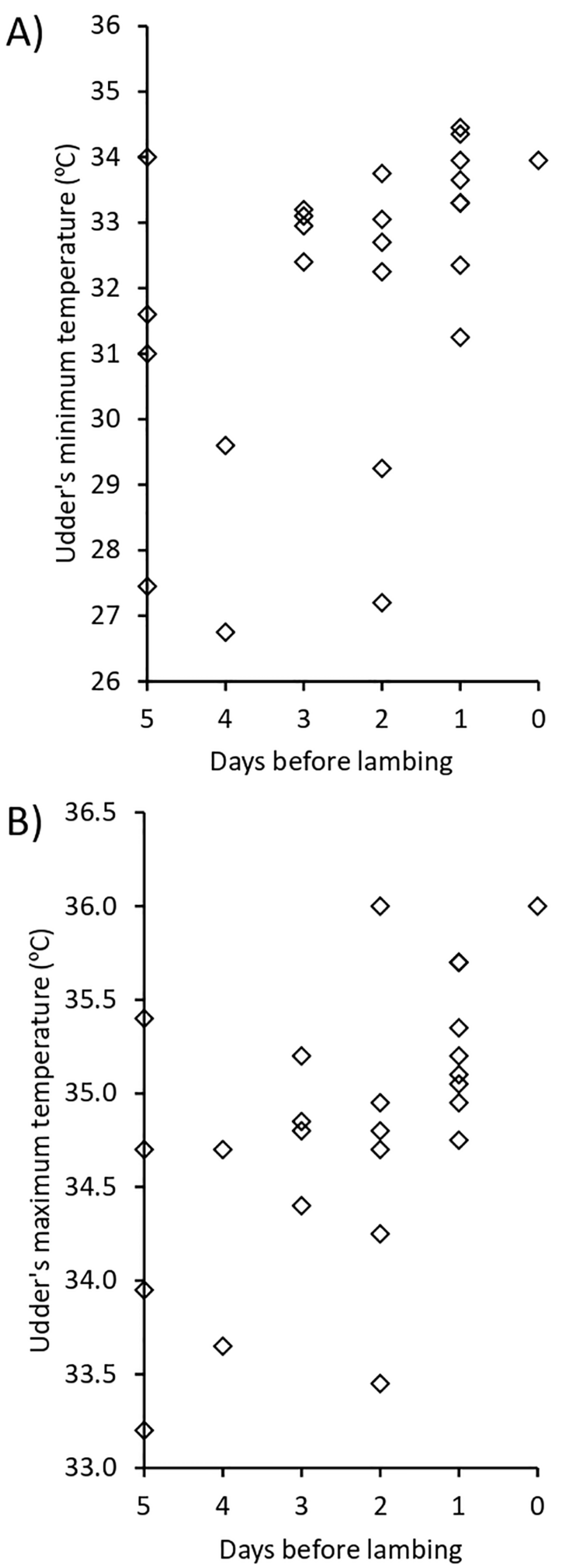

FIGURE 2
Relationships between the number of days before lambing and the udder's minimum **(A)** and maximum **(B)** skin temperatures (°C). Five days before the expected lambing date, the minimum and maximum temperatures of the udder were recorded in Corriedale ewes using an infrared thermal camera. A single operator took all photos of the ewes standing at the same distance, capturing the back view.

Udder size and teat morphology do not appear to influence the establishment or the early evolution of the ewe-lamb bond. This observation differs from previous reports of an association between ewes' udder and teat scores and lambs' growth and survival (Griffiths et al., 2019a, Griffiths et al., 2019b). However, udder scores reflect multiple attributes simultaneously, rather than size or shape alone. As the time to first acceptance to the udder is related to the probability of lamb survival (Cloete, 1993; Miller et al., 2010), the effect of udder score may be more related to other factors, such as milk yield or composition, and not to its relation with the ewe-lamb behaviors after birth. From a practical point of view, this is relevant, as the main determinants of newborn lambs' access to the udder appear to be unrelated to factors that breeders or technicians usually do not control, such as udder shape.

When udder measurements were recorded closer to the lambing date, the udders were warmer, highlighting a promising use of infrared thermal imaging of udder skin surface temperature as a non-invasive method to monitor the lambing process. However, studies should consider whether these measurements are helpful for the reliable prediction of lambing date. The higher the udder surface temperature, the more heat it was losing. Therefore, this greater heat loss from the udder could be explained by a higher frequency of ewes with a greater ratio of contact area to udder volume. However, udder surface temperature was not related to udder volume, so this does not explain this result. Therefore, other characteristics not controlled in this study, such as wool cover, could explain this variability in heat loss. In this sense, Alary et al. (2023, Alary et al., 2025a, Alary et al., 2025b) reported that inguinal wax odor is the primary attractant for newborn lambs, guiding them to the teat, and similarly, discarded a relationship between the udder size and/or shape and the attractant. Unfortunately, in this study, other relevant udder characteristics, such as the wool-covered surface, which may influence odor release, were not determined. Thus, it cannot be ruled out that the surface covered by wool also influences the release of heat into the environment and, consequently, the temperature of the fleecy surface.

It should also be considered that this study was performed with an out-of-season lambing, in which ewes were induced to ovulate in spring, and therefore, lambed in autumn. Although the general mechanisms controlling parturition and maternal behavior are the same as in spring parturitions, the relationship between metabolic status and maternal behavior may differ. In effect, when ewes lamb in autumn, at least in extensive grazing systems, their gestation takes place in spring, with better conditions than when they lamb in spring, after a winter gestation (Menant et al., 2022). Thus, ewes that lamb in autumn have greater body weight and body condition score than those that lamb in spring (Menant et al., 2022). However, the ewe-lamb bond at parturition is weaker in autumn, likely due to evolutionary constraints (Menant et al., 2022). Other constraints, as becoming pregnant when a lamb remains still suckling, can also affect the following ewe-lamb bond when out-of-season lambings are inserted in accelerated reproductive programs, even if the ewes' body condition is not affected at lambing (Ungerfeld et al., 2021). Thus, it is crucial to recognize that the present results should not be viewed as a general rule; consequently, the general hypothesis should not be discarded without testing it in spring-lambing ewes.

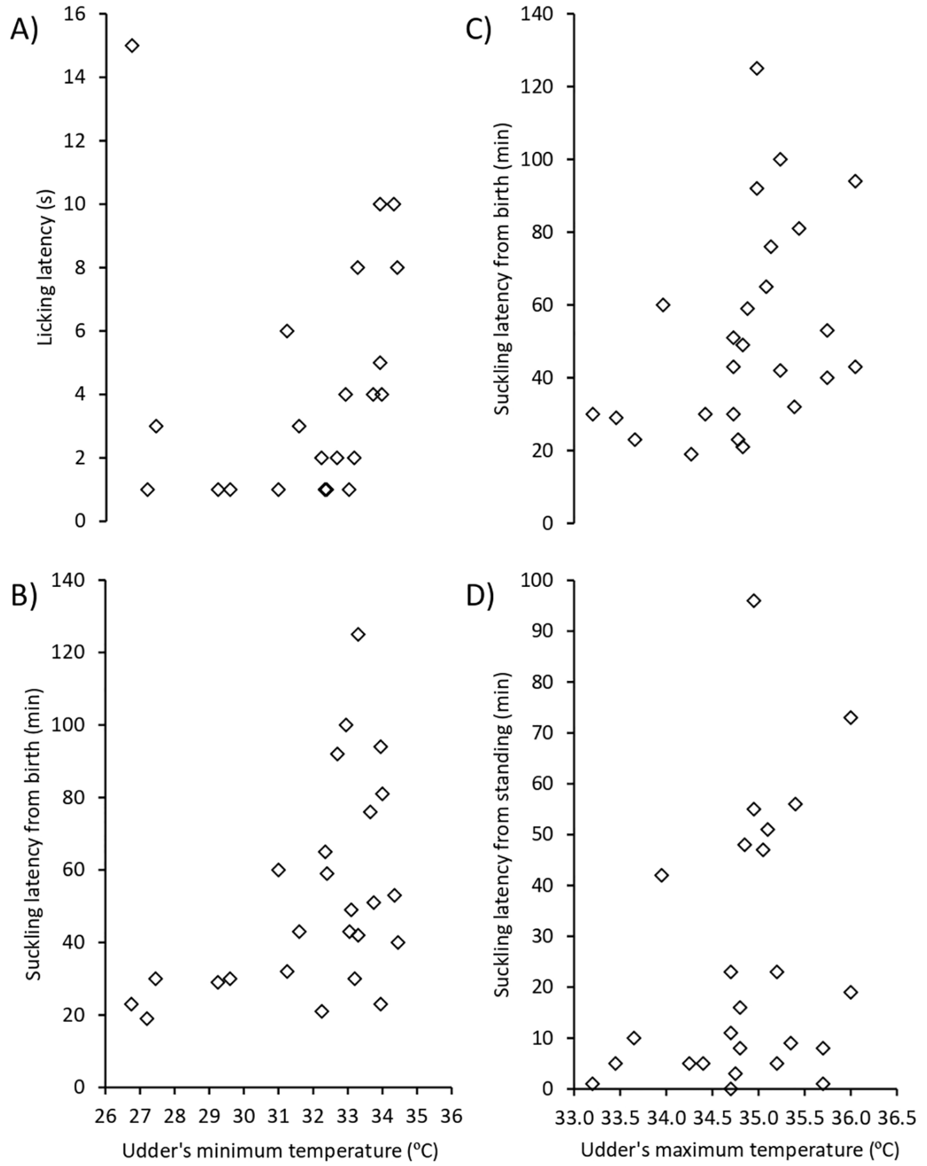

FIGURE 3
Relationships between **(A)** the minimum skin udder of the ewe and her latency to lick its lamb for the first time, **(B)** the minimum and **(C)** maximum skin udder temperatures of ewes, and the latency of their lamb from birth to first suckle, and **(D)** from first time standing to first suckle. Udder characteristics were measured 5 days before the expected date of parturition in an out-of-season lambing in Corriedale ewes.

TABLE 4 Correlation coefficients (r, Spearman tests) and P-values between the ewes' udder and teats characteristics and the ewes' and lambs' behaviors recorded during separation-reunion tests performed 24–36 h after lambing in autumn-lambing Corriedale ewes.

Udder and teats characteristics	Ewes vocalizations		Lamb vocalizations		Ewe-lamb distance (m)		Latency to reunite (s)		Latency to suckle (s)	
	r	P	r	P	r	P	r	P	r	P
Volume (cm^3)	0.16	0.28	0.07	0.63	-0.05	0.71	-0.15	0.31	0.17	0.22
Maximum skin surface temperature (°C)	-0.20	0.17	-0.03	0.84	0.11	0.47	0.15	0.31	0.002	0.98
Minimum skin surface temperature (°C)	-0.19	0.19	0.14	0.33	0.07	0.64	0.10	0.50	0.21	0.15
Teat length (cm)	0.01	0.98	-0.18	0.42	-0.14	0.53	-0.06	0.79	-0.30	0.17
Teat width (cm)	0.06	0.80	-0.22	0.30	0.004	0.99	-0.31	0.16	0.16	0.46
Teat angles (α°)	-0.06	0.68	0.09	0.54	-0.00	0.96	0.05	0.76	0.14	0.34

In conclusion, a negative correlation was observed between the udder skin surface temperature and the time it took for the mothers to lick their lambs for the first time, as well as the time it took for the lambs to ingest colostrum for the first time. However, the morphological characteristics of the udder and teats recorded before birth were not found to be related to the behavioral development of the ewe-lamb bond.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The Comisión de Ética approved all the procedures en el Uso de Animales (CEUA), Facultad de Agronomía (UdelaR. Uruguay). The study was conducted in accordance with the local legislation and institutional requirements.

Author contributions

RU: Conceptualization, Funding acquisition, Methodology, Project administration, Resources, Supervision, Writing – original draft, Writing – review & editing. OM: Data curation, Formal Analysis, Investigation, Visualization, Writing – original draft, Writing – review & editing. RP-C: Conceptualization, Project administration, Writing – review & editing. AF-d-M: Conceptualization, Funding acquisition, Investigation, Methodology, Project administration, Resources, Visualization, Writing – review & editing.

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Conflict of interest

The authors declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

The authors RU, AF-d-M declared that they were an editorial board member of Frontiers, at the time of submission. This had no impact on the peer review process and the final decision.

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