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Behavioral, Physiological and Hormonal Changes in Primiparous and Multiparous Goats and Their Kids During Peripartum

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Simple Summary: In recent years, the implementation of strategies to make goat farms more profitable has been based on the importance of newborn care associated with maternal behavior and thus favoring the survival of the offspring. In addition to the above, it has been observed that maternal experience can affect the care behavior towards the offspring, in such a way our work team seeks to generate strategies that help goat producers to identify problems in the peripartum period and make farms more efficient, increasing the viability of the offspring. Therefore, our objectives of this study were to determine the effect of maternal experience on the behaviors that goats present in the pre- and postpartum period, as well as on plasma concentrations of progesterone and estradiol. These results show that maternal experience affected some behaviors in the peripartum period of the mother and the vitality of the kid.

Abstract: The objective of this study was to evaluate the effect of maternal experience on behavior, progesterone and estradiol concentrations, weight and body condition in goats in the peripartum period, as well as the behavior and weight of the kids in the first hours after birth. Twenty multiparous and 10 primiparous dairy goats were enrolled. Behaviors such as walking, isolation, aggression, eating, inactivity and rumination were recorded in females during the last three days prior to the day of delivery, as well as the behaviors of the dam and her progeny in the first 2 h postpartum and the ability of the mother to discriminate between own kid and the alien one (selectivity test) at 2 h postpartum. Gestational and postpartum plasma progesterone and estradiol concentrations were determined. In the prepartum period there was a higher percentage of primiparous goats that were eating and remained less inactive compared to multiparous goats ($p < 0.05$). During the postpartum period, the lick latency to the kid was shorter in multiparous than in primiparous goats ($p = 0.015$). There was a greater proportion of kids born from multiparous (67%) than from primiparous (27%) that stood up in the first 30 min postpartum ($p < 0.0001$). Therefore, the proportion of multiparous kids (33%) than primiparous kids (9%) that were nursed within the first hour after birth was also higher ($p < 0.0001$). Progesterone and estradiol concentrations were not affected by maternal experience, neither in the prepartum nor the postpartum. In conclusion, maternal experience affected some behaviors at peripartum of the dam and vitality in the kid; however, the differences in behavior were not accompanied by differences in the variations in circulating estradiol and progesterone levels in the dam.

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1. Introduction

In reproductive terms the process of birth in goats, as in other species, is divided into three stages; (a)—the dilation phase: from the moment at which parturient goats appear restless, seek isolation and separate from their companions until the appearance of the fetal bags through the vulva, (b)—the expulsion phase: from the moment the fetal sacs appear, until the complete expulsion of the fetus or fetuses, and (c)—the expulsion of fetal membranes: the period that elapses from the expulsion of each fetus until the complete elimination of the placenta [1,2].

On the other hand, when we address the behavioral aspect, the birth of the offspring triggers behavioral changes, particularly the display of maternal behavior. Maternal care ensures offspring survival, contributes to reproductive success and, therefore, to productive profitability [3–5]. The study of maternal behavior has also focused on elucidating and addressing the causes of mortality of newborns in production species [6]. It has been determined that the main factors that predispose mortality of offspring on farms are (a) hypothermia due to excessive heat loss, which may be associated with a failure of mothers to clean their offspring; (b) starvation or death by hunger when the offspring is very weak and cannot reach the nipple and the mother also shows poor maternal motivation to care for it; (c) maternal malnutrition during pregnancy, which implies poor development of the offspring at birth, poor maternal instinct and low availability of colostrum [7].

In goats, the mortality rate reported by various studies in goats ranges from 7 to 51%, depending on the conditions in which the animals are kept and the prevailing climate (for review [7]), however, it is also reported that depending on the age at which the offspring are found, the survival rate will be. For example, in a study in Ethiopia carried out on Boer goat herds, it was reported the 25th, 50th and 75th percentiles of kids survival time were 5, 162 and 1300 days, respectively [8].

Therefore in the case of sheep and goats, the study of maternal behavior has been carried out mainly in order to contribute to detect predisposing factors to perinatal mortality [4,9]; in both species, some studies reported differences in the expression of maternal behavior due to maternal experience. In the case of sheep, it was reported that ewes giving birth for the first time have greater issues in terms of caring for their neonate and, especially, lactation is delayed, predisposition to weakness in the neonate and possible abandonment, offspring of primiparous ewes are lighter and have a higher risk of mortality than offspring of multiparous ewes [10–13]. In the case of goats, little information is available on maternal experience and behavior at parturition. Lickliter (1982) reported that multiparous goats became isolated earlier and showed more aggressive behavior towards conspecifics than primiparous goats [14]. Another study in goats, which explored the effects of factors such as sex and litter size, found that male kids and from single births suffered more during birth and had a delayed time to reach the udder, but seemed to recover quickly within the first hour postpartum [15]. Unfortunately, this study was only performed on females giving birth for the first time, so the interaction of the effect of maternal experience and the factors mentioned could not be determined. Another study, also carried out in primiparous goats, demonstrated that when they received aversive or gentle handling during the middle of gestation, the females with aversive handling were the only ones that had fetal losses, the cleaning latency was delayed at breeding and there was a tendency for their kids to have longer latencies to reach the udder and suckle [16]. On the other hand, the mortality of kids was also related to the maternal experience of the female, since, as the number of births increases, the survival rate of the offspring increments [17].

Meanwhile, it is known that maternal behavior in some mammals is controlled by the effect of hormones [18]. In ewes, the interaction of progesterone, estrogens and oxytocin was found to facilitate the display of maternal behavior [3,19]. Likewise, in non-pregnant ewes

when a high-dose estradiol or estradiol plus progesterone treatments were used, greater maternal response was induced in multiparous ewes than primiparous ewes [20,21]. In the case of sex steroids, such as progesterone and estrogens, they are essential in triggering maternal behavior in sheep [22], particularly, and estrogens increase oxytocin mRNA expression [23]; they favor the recognition of the offspring through olfaction and facilitates the display of maternal behavior [3,24]. However, although it is possible to speculate that the hormonal changes reported in sheep according to maternal experience are similar to those in goats, to the best of our knowledge there are no studies linking these elements in this last species.

Other proprioceptive factors are involved in the proper display of maternal behavior, and this may be affected by maternal experience as is in the case of attraction to amniotic fluid. When amniotic fluid was removed from lambs at birth, multiparous ewes showed reduced maternal behavior, whereas in primiparous ewes such behavior was completely suppressed [24]. Although evidence in ewes shows that estrogens and progesterone directly trigger maternal behavior, in turn, maternal experience has a fundamental role on maternal behavior. However, in goats there are no studies reporting this association. Consequently, our hypothesis is that maternal experience is associated with maternal–kid behavior in peripartum and with the variations in circulating estradiol and progesterone concentrations. Hence, the objective of this study was to evaluate the effect of maternal experience on behavior, progesterone and estradiol concentrations, weight and body condition in goats in the peripartum period, as well as the behavior and weight of the kids in the first hours after birth.

2. Materials and Methods

This work was approved by the Institutional Sub Committee for the Use and Care of Experimental Animals of the Graduate Program in Production Sciences and Animal Health, UNAM, with protocol number SICUAE-DC-2021/2-3.

2.1. Animals, Feeding and Housing Conditions

The study was carried out in the goat production module of the Centro de Enseñanza Agropecuaria belonging to the Facultad de Estudios Superiores Cuautitlán of the Universidad Nacional Autónoma de México (UNAM). It is located in the State of Mexico, north latitude 19°40′50″ and west longitude 99°12′25″, at 2250 m above sea level. The reproductive management period was carried out at the end of August during the summer rainy season. Births occurred at the beginning of February during the winter dry season.

Twenty multiparous goats (with at least one previous gestation, parturition and lactation experience) and 16 primiparous goats (without any previous gestation, parturition and lactation experience) were selected from a dairy herd in which there were no purebred animals because they came from a flock in which crosses between the French Alpine and Toggenburg breeds prevailed. Depending on the data obtained, it is observed that the sample size varies since it was not always possible to make all the measurements on all the goats. For the physiological and behavioral measurements, data from only one year were used. While for the hormonal data, the experimental process was repeated with a similar number of animals and blood samples were taken in two consecutive years during the same periods, to obtain an adequate number of samples. The goats were fed a diet that covered their nutritional requirements according to NRC [25] and it was composed of a commercial feed (18% Crude Protein, Technical Nutrition®), corn silage, oat hay, alfalfa hay and water *ad libitum*. The goats were housed in two pens (12 × 15 m), one pen for multiparous goats and another for primiparous goats, where they remained until the end of the experiment. To concentrate litter in a single week, estrus was synchronized [26] with a procedure that consisted of applying sponges containing the progestin Cronolone (20 mg, Chrongest CR®, Intervet, Carbajosa de la Sagrada, España) vaginally to each goat. On the 11th day after the sponge was placed, an intramuscular injection of 5 mg of Dinoprost-PGF2α Thromethamine (5 mg, Lutalyse®, Zoetis, Buenos Aires, Argentina)

was applied. The sponge was removed after 12 days, and immediately 350 IU/animal of Equine Chorionic Gonadotropin (NOVORMON 5000® Virbac, Carros, France) was injected intramuscularly. After removal of the sponge, the females were exposed to sexually active males (one per pen, males ranged in age from 3 to 5 years and weighed an average of 60 kg, they were also crossbred animals like the females), which were fitted with a harness equipped with a colored wax marker (Raidex®, Dettingen, Germany). At approximately day 60 post-service, gestation diagnosis was made by real-time ultrasound (Welld 9618®, Shenzhen, China) with a 3.5 MHz transabdominal transducer. At the time of gestation diagnosis all animals were identified with earrings.

2.2. Experimental Process

Once the number of pregnant animals was determined, they were categorized, depending on maternal experience, into two groups and housed in two different pens: (1) Clinically healthy pregnant multiparous goats (n = 20, 3–4 previous births, 54.2 ± 2.2 kg weight and 3–5 years old). (2) Clinically healthy pregnant primiparous goats (n = 10, no previous births, 44.3 ± 1.4 kg weight and 1–2 years old). The number of goats that gave birth and their description was as follows: 20 multiparous goats gave birth (5 single births, 12 double births and 3 triple births) from which 23 males and 15 females were born. The 10 primiparous goats gave birth (5 single and 5 double kidding) to 8 males and 7 females.

The births of the goats took place in both shifts, it was found in this experiment that 43% of the births occurred in the morning shift (between 5:00 a.m. and 12:59 p.m.), while 57% occurred in the afternoon shift (between 1:00 p.m. and 9:00 p.m.) Outside of that shift, no births were recorded.

2.2.1. Measurement of Prepartum Behavior

One week prior to the expected kidding date, each goat was fitted with an identification number collar (Gentile Animal Identification Systems®, Ciudad de México, México) to monitor the goats from a distance. Direct observations were made three days prior to the estimated kidding date and on the day of kidding. This meant that there was one trained person per group who stood outside and took notes directly on a pre-formatted sheet. These observations were made using the scan samples method where the entire group of individuals is viewed quickly at a glance or scanned at regular intervals. The behavior of each individual at that moment was recorded [27,28], every 15 min during two periods of the day (8:00 a.m. to 11:00 a.m. and 4:00 p.m. to 7:00 p.m.). Given that most of the literature indicates that in goats 90% of births occur between 7:00 a.m. and 7:00 p.m. [29–32], it was decided to make the measurements in two periods within this schedule. The identity of each animal and its behavior were recorded during each the sweep. The percentage of occurrences of each behavior out of the total number of observations was calculated, accounting for the total morning and afternoon observations. The behaviors recorded are shown in Table 1.

Table 1. Definition of behaviors recorded in goats in the prepartum period.

Conduct	Description
Walking	Locomotor activity and/or moved around the corral.
Eating	When the goat was ingesting feed or its head was in the feed troughs.
Isolation	When the goat moved more than 3 m away from the herd or the nearest animal.
Aggression	When the goat showed signs of aggression towards any other member of the herd.
Rumination	When the goat was chewing the regurgitated feed.
Inactivity	When the goat was not performing any of the above behaviors.

2.2.2. Measurement of Behavior During and Immediately After Parturition

During these periods, direct observations were made to identify prodromal signs of parturition (goat restlessness, abdominal contractions, low-pitched bleating). Once a goat showed signs of parturition (appearance of the amniotic sac through the vulva), an area of

2 × 2 m was delimited with metal panels in the pen where the goat lived with the herd. From this moment on, the experimental subject was observed for 120 min continuously. An observer recorded the latency, frequency and duration of the goat and kid behaviors, which are described in Table 2. When the kid did not nurse within 120 min of observation, for the analysis, latency was assigned a value of 7200 s.

Table 2. Definition of behaviors recorded in goats and kids during and immediately after parturition.

Conduct	Description
Time elapsed between amniotic sac and limb emergence	When the kid's limbs were observed through the birth canal.
Time elapsed between limb emergence and expulsion of the offspring	When the kid was fully expelled through the birth canal.
Lick latency	When for the first time the female cleaned, by way of grooming, the kid after its expulsion.
Nursing latency	When for the first time the female allowed the kid to ingest colostrum and was considered only when the episode lasted more than 5 continuous seconds.
Vocalizations of the dam	Sounds emitted with the mouth open or closed.
Latency of the kid trying to stand up	When the kid made first attempt to stand up, either assisted with one or both limbs and with the head or with the trunk.
Latency of kid standing	When the kid is stand up, in four legs for the first time.
Vocalizations of the kid	Sounds emitted with the mouth open or closed.

When there were complications during delivery, the females were assisted by people with experience in obstetric management of goats. There were always at least two people a day who had these skills. It was considered a dystocic delivery [33,34], and, therefore, it was decided to help the female to give birth when the following conditions existed: (1) one hour had passed since the amniotic sac appeared and there was no progress; (2) when more than half an hour had passed since the kid's limbs appeared and there was no progress; (3) in addition, if it was noticed that there was a yellowish color and the extremities of the kid were visible and there was no progress, attention was almost immediate. In such circumstances, the female was helped either by accommodating the product and letting it come out with the contractions or by extracting the kid. When a goat was born very weak, it was removed from its mother and cleaned and fed artificially by extracting colostrum from its mother and feeding it with an esophageal tube. These kids were kept in a warm place, but despite all the care, in most cases these animals did not survive. When the kids were active and had a sucking reflex, but for one reason or another were unable to suckle during the first 2 h of observation, they were attached to their mother so that they would suckle, and in some cases they were helped with a bottle by providing colostrum from their mothers.

2.2.3. Maternal Selectivity Test at 2 h Postpartum

This test was performed on each goat 2 h after kidding and in the same pen where the kidding occurred. This test was used to measure the level of rejection or acceptance towards the own and other goats' offspring. The procedure and the behaviors recorded were similar to that described by Poindron et al. [35]. The test consisted of observing the goat in two consecutive periods (3 min each), in the first one the goat was tested in the presence of a foreign kid (with similar age to the own and coming from the same group) and the second one in the presence of its own kid. The records were taken by direct observation and the following behaviors were noted in the mothers: (a) low bleats (low frequency vocalizations emitted with mouth closed); (b) high bleats (high frequency vocalizations emitted with open mouth); (c) time in proximity of the kid to the inguinal area; (d) refusals of the kid to approach the udder; (e) acceptances of the kid to approach the udder; (f) aggression towards the kid.

Once the test was completed, both the mother and the offspring were released and reunited in the kidding pen. The foreign kid was also reunited with its mother.

2.2.4. Maternal Motivation Score

This variable will be recorded within the same birth pen, while the kid is handled to measure the above. It will be noted in three categories, identified by a number and was adapted by Everett-Hincks et al., 2004 [36]: Score 1 = little or no interest: when the mother is not interested in handling her offspring, she turns away or does something else and does not emit low bleats either. Score 2 = medium interest: when the mother does not approach her offspring, but she follows her with her eyes and emits low bleats. Score 3 = very interested: when the mother follows the place where her offspring is, she approaches it, sniffs it and licks it, in addition to continuing to vocalize.

2.2.5. Determination of the Hormone Profile Before and After Birth

Blood samples were collected by venipuncture in the jugular vein with a 21 G × 38 mm vacutainer needle. The samples were collected in tubes of 5 mL each, with anticoagulant containing Ethylene diamine tetra acetate (EDTA). The samples were transported to the laboratory of Animal Reproduction of the Facultad de Estudios Superiores Cuautitlán, UNAM, and were centrifuged at 3500 r.p.m. 20 min and at 4 °C to obtain the plasma, which was separated and placed in Eppendorf tubes, identified and stored in a freezer at −20 °C, until its determination. Progesterone and estradiol determinations were performed in the Reproduction Laboratory of the FMVZ-UNAM by ELISA technique, with a commercial kit (DRG Diagnostics©, Marburg, Germany), the analytical sensitivity of the assay was 10.6 pg/mL, the intra-assay coefficient of variation for estradiol was 9.99%, for progesterone the analytical sensitivity of the assay was 0.045 ng/mL and the intra-assay coefficient of variation was 8.94%. The blood samples collection was done for all goats in the experiment at 60, 90, 120, 130, 137, 140, 142 and 144 days of gestation. Also, at the time of parturition (when half of the kid was visible), and subsequently at 2, 6, 24 and 48 h postpartum. Pregnancy sampling was done on fasting animals in the morning between 08:00 a.m. and 09:00 a.m. Blood samples were obtained from 13 primiparous goats and 16 multiparous goats. In cases where the sample was not obtained on the first attempt, no more than 1 min passed before a second attempt was made. The sample was taken by people who had experience in this procedure.

Due to the limited sample size per group and the problems encountered during the pandemic in storing and obtaining reagents to process the samples, some of them were lost. Therefore, it was decided to take more samples in the similar periods as the first experiment and to take advantage of a second experiment that was being developed with similar handling and conditions to test other objectives of a larger research project.

2.2.6. Physiological Parameters of Mother and Offspring

On the goat: Determination of body weight and body condition during gestation: These evaluations were carried out between 08:00 a.m. and 09:00 a.m. in the morning before the animals were fed. The females were weighed with the aid of a digital precision scales of 100 g (Rinho® Lopez Mateos City, México) on days 70, 125 and 134 during pregnancy and at birth, as well as on day 15 of lactation. The animals were contained in the pen with the aid of 4 panels of 2 × 1 m. Body condition was measured in the same periods, i.e., as weight using the method described by Walkden-Brown et al. (1997) with a scale of 1 to 5 [37]. At the end of the measurements, the females were released into the pen where they were housed.

On the kid: (a) Body weight: the kids were weighed at 3 h after birth, after the selectivity test and at 7 days of age. (b) Rectal temperature: during the weighing period, rectal temperature was recorded with the aid of a digital thermometer (Hergom®, Mexico City, México) previously disinfected. (c) Surface temperature: during the same period of weighing, the external temperature was recorded with the help of a digital gun thermome-

ter (Steren® HER-424, Mexico City, Mexico), the temperature was taken by placing the thermometer at 5 cm in the middle part of the neck [38]. (d) Mortality rate of kids: the number of goats that died during the first 7 days postpartum was recorded in each group.

2.3. Statistical Analysis

The physiological variables, such as body condition (gamma) and body weight (gaussian) and for the analysis of hormone concentrations of progesterone (gaussian) and estradiol (lognormal), were analyzed by ANOVA for repeated measurements over time, using the Proc GLIMMIX procedure of SAS OnDemand for Academics (v. 3.1.0, SAS Institute Inc., Cary, NC, USA). The model included as fixed-effects maternal experience (primiparous vs. multiparous), time, and the interaction between maternal experience and time, including the goat within each maternal experience as a random effect. The number of offspring was included as a covariate in the model. The covariance structure used was autoregressive of the first order.

A Kolmogorov–Smirnov Test was performed using Lilliefors probability in postpartum behaviors and selectivity and it was determined that these data did not have a normal distribution, so it was proceeded to use the Mann-Whitney *U* test was used to compare behaviors during and immediately after parturition between primiparous and multiparous goats. The comparison between frequencies and duration of behaviors during the selectivity test shown by goats with their own and a foreign kid were analyzed using the Wilcoxon test. The proportion of kids that rose or suckled, the prepartum behavior data and proportion of kids that died in the first week of life were analyzed with a Pearson's chi square test. The model included maternal experience (primiparous vs. multiparous) as fixed-effects. The time of delivery was not included in the model to analyze this data. SYSTAT 13 (SPSS Inc.; Chicago, IL, USA) was used for all the analyses. Results were expressed as mean ± SEM and were considered significant at an alpha level $\leq$0.05. A trend was considered with alpha values where the these ranged between 0.05 and 0.10.

3. Results

3.1. Prepartum Behaviors in Goats

During the observation carried out in the three days prepartum and on the day of parturition, it was found that in the primiparous group a higher percentage of goats were eating (p = 0.049) and remained less inactive (p = 0.019) compared to multiparous goats. No significant differences were found for all other behaviors between primiparous versus multiparous goats (Figure 1).

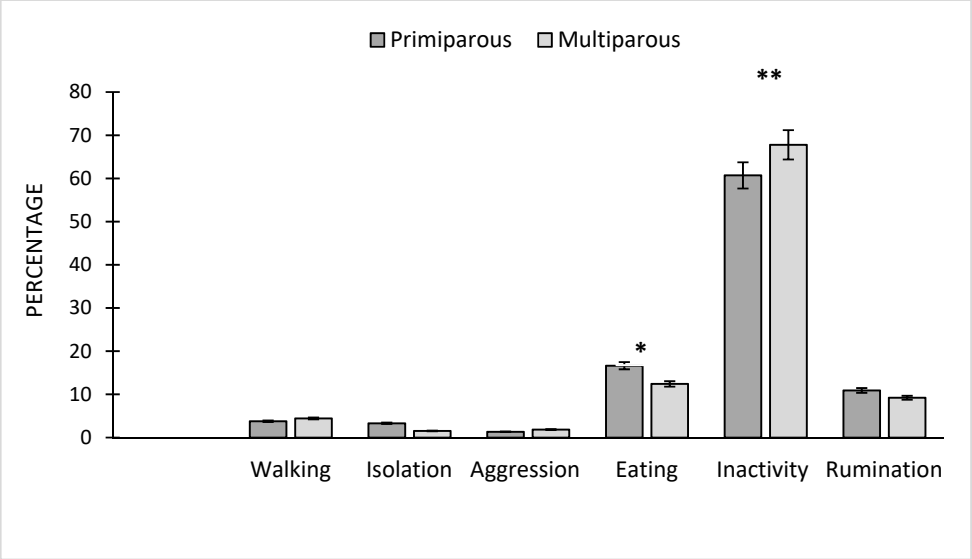

Figure 1. Impact of maternal experience on goat behaviors recorded during three days prepartum and on the day of parturition (mean percentage ± SEM). Observations were made every 15 min in the morning and afternoon (8:00 a.m. to 11:00 a.m. and 4:00 p.m. to 7:00 p.m.). Differences between groups at each behavior are indicated by asterisks (* $p < 0.05$ and ** $p < 0.01$).

3.2. Behavior of the Goat and Its Offspring During and Immediately After Parturition

Of the 10 primiparous goats registered, 15 live kids were born, of which only 11 could be recorded. Meanwhile, of the 20 multiparous goats, 38 kids were born, of which 4 were born dead and 34 alive. Of the 34 alive, only of 24 was possible to record their behavior.

The latency to lick the kid was lower in multiparous goats than in primiparous goats ($p = 0.015$, Table 3).

Table 3. Behaviors (mean ± SEM) recorded throughout the observations made on the goats and their kids of the primiparous and multiparous groups during the first two hours after parturition.

Behavior	Primiparous N = 10	Multiparous N = 13	*p*-Value
Time elapsed between amniotic sac and limb emergence (s)	300.0 ± 89.44	814.2 ± 194.74	0.127
Time from limbs to expulsion of the kid (s)	343.6 ± 99.44	324.5 ± 53.20	0.758
Lick latency (s)	365.6 ± 188.56	60.5 ± 24.09	0.015
Number of vocalizations of the dam	509.4 ± 242.38	153.3 ± 27.35	0.501
Maternal motivation score	2.0 ± 0.23	2.14 ± 0.16	0.584
Latency of the kid trying to stand up (s)	1704.0 ± 753.45	680.0 ± 87.92	0.384
Latency of kid standing (s)	3349.0 ± 775.15	2287.5 ± 397.9	0.206
Nursing latency (s)	6114.5 ± 585.2	5010.0 ± 454.49	0.175
Number of vocalizations of the kid	157.3 ± 36.30	123.12 ± 23.88	0.407

There was a greater proportion of kids born from multiparous (67%) than from primiparous (27%) that stood up in the first 30 min postpartum ($p < 0.0001$). Therefore, the proportion of multiparous kids (33%) than primiparous kids (9%) that were nursed within the first hour after birth was also higher ($p < 0.0001$).

Finally, no differences were found between primiparous and multiparous goats in the other behaviors recorded in the postpartum period of both mothers and kids ($p > 0.05$, Table 3).

3.3. Maternal Selectivity

No significant differences were found between primiparous versus multiparous goats in the behaviors recorded in this test (Table 4). However, when comparisons were made

within the group, comparing the behaviors towards their own versus the foreign kid (Table 4), the frequency of low bleating was higher during the test with the foreign kid than with their own kid, both in multiparous ($p < 0.020$) and primiparous females ($p = 0.012$). The frequency of loud bleating was higher in the presence of the foreign kid than with the own kid, only in the case of the primiparous group ($p = 0.028$), while it was a tendency to be higher in presence of own than alien kid in the case of multiparous group ($p = 0.080$). For multiparous goats, the time spent close to the udder was greater for their own kid than for the foreign kid ($p = 0.001$), while in the primiparous group this comparison showed a trend for their own kid rather than for the foreign kid ($p = 0.068$).

When analyzed within maternal experience, we found that in the multiparous group the rejection of the kid when it approached the udder did not differ for the foreign kid than for their own kid ($p > 0.05$), while primiparous mothers tended to reject the alien or foreign more than their own ($p = 0.059$). The frequency of acceptance of the udder was higher for their own kid than for the foreign kid in multiparous groups ($p = 0.017$), while in primiparous goats this comparison only was a tendency ($p = 0.066$). The frequency of aggression was higher towards the foreign kid compared to their own kid, but this effect was only observed in the multiparous group ($p = 0.041$). While in primiparous there were no differences.

Table 4. Behaviors recorded (mean ± SEM) in primiparous and multiparous goats during a selectivity test performed at 2 h postpartum.

Behavior	Primiparous (n = 9)		Multiparous (n = 16)	
	Own Kid	Foreign Kid	Own Kid	Foreign Kid
Number of low bleats	15.33 ± 3.83^{a}	32.88 ± 7.35^{b}	15.43 ± 4.87^{a}	37.75 ± 6.98^{b}
Number of high bleats	0.66 ± 0.37^{a}	13.44 ± 7.05^{b}	0.56 ± 0.40^{A}	10.50 ± 5.74^{B}
Time near the udder (s)	13.66 ± 8.9^{A}	0 ± 0^{B}	33.37 ± 12.2^{a}	4.5 ± 3.19^{b}
Number of rejections of kid	0 ± 0^{A}	0.55 ± 0.24^{B}	0 ± 0	0.37 ± 0.25
Number of acceptances to the udder	1.33 ± 0.60^{A}	0 ± 0^{B}	1.25 ± 0.23^{a}	0.5 ± 0.24^{b}
Aggression	0 ± 0	0.55 ± 0.44	0 ± 0^{a}	0.62 ± 0.27^{b}

Different lowercase literals indicate significant within-group differences between their own kid versus foreign kid test, ($p \leq 0.05$, Wilcoxon). Different capital letters indicate a tendency to differ within groups between own-versus-foreign kid test ($p = 0.06$, Wilcoxon). No differences were found between primiparous and multiparous goats (Mann–Whitney *U* test).

3.4. Progesterone and Estradiol Concentrations of Goats Before and After Parturition

There was no effect of maternal experience on plasma estrogen (Figure 2A) and progesterone (Figure 2B) concentrations during gestation and postpartum ($p > 0.05$, Figure 1). Estradiol and progesterone concentrations were not affected either by the interaction between time or maternal experience ($p > 0.05$). Estradiol concentration varied over time ($p < 0.0001$). As shown in Figure 2A, estradiol concentration increased as gestation progressed and decreased after parturition. In progesterone concentrations, the levels decreased as gestation advanced, reaching the lowest values 2 days after birth (Figure 2B).

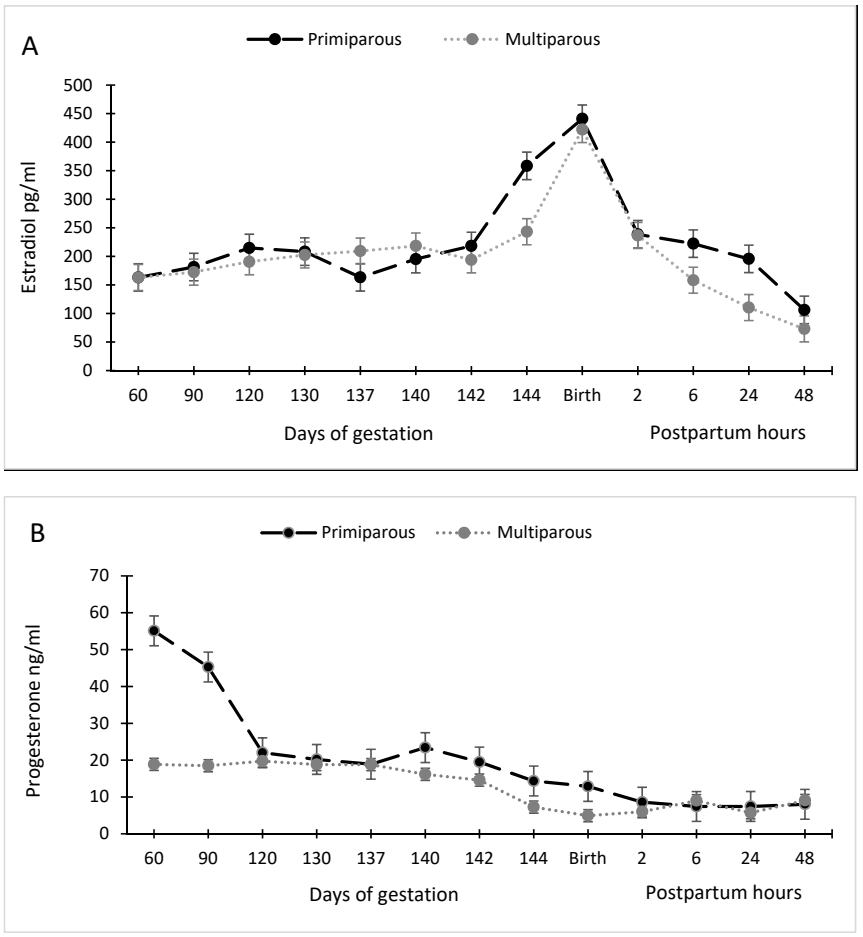

Figure 2. Estradiol (**A**) and progesterone (**B**) concentration (mean ± SEM) comparing primiparous (n = 13) versus multiparous goats (n = 16) during gestation and postpartum.

We performed the statistical analysis of the estradiol/progesterone ratio and found no differences by parity ($p = 0.121$), and we also found no interaction between parity and time ($p = 0.485$). The estradiol/progesterone ratio was not affected by parity (primiparous goats: 129.83 ± 20.01 vs. multiparous goats: 179.67 ± 18.02, $p = 0.121$).

3.5. Physiological Parameters of the Goats and Their Kids

3.5.1. Goat Body Weight

Multiparous goats were heavier than primiparous goats (group effect: $p = 0.0102$), also, there was an effect due to time ($p < 0.0001$). In this sense, the weight of the females of both groups increased as gestation progressed and decreased as kidding approached (Figure 3). There was no effect in relation to the interaction between time and maternal experience ($p > 0.05$).

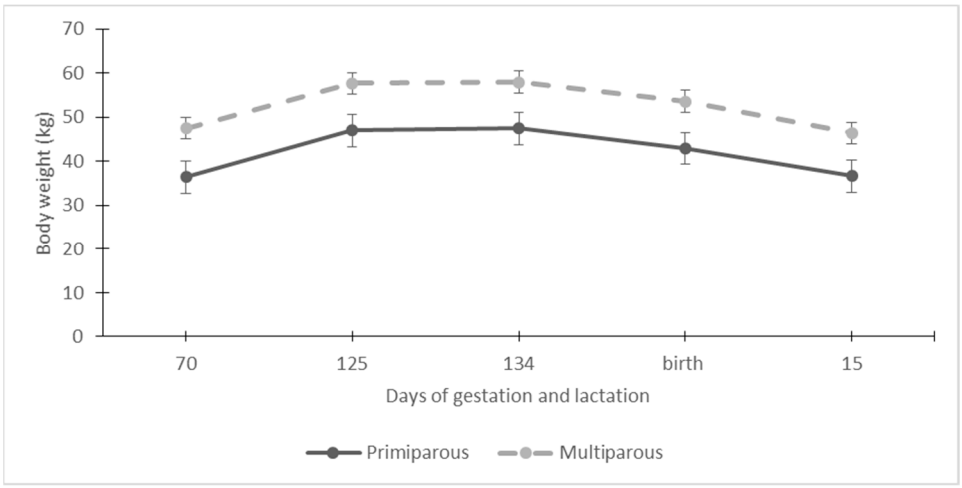

Figure 3. Body weight (mean ± SEM) of primiparous (n = 9) and multiparous (n = 20) goats during gestation and postpartum.

3.5.2. Goat Body Condition

Body Condition Scoring (BCS) of goats was not affected by maternal experience nor by the interaction between time and maternal experience ($p > 0.05$), however, there was an effect due to time ($p < 0.001$). As shown in Figure 4, body condition of females in both groups increased as gestation progressed and decreased near parturition.

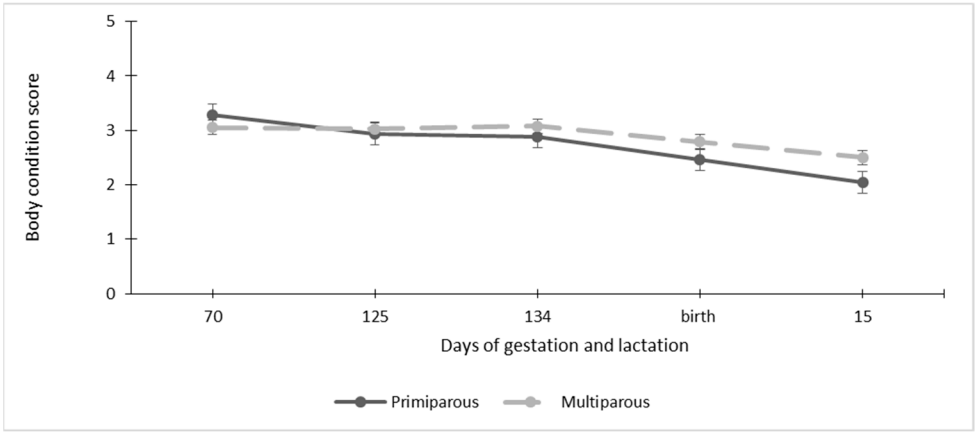

Figure 4. Body condition score (mean ± SEM) in primiparous (n = 9) and multiparous (n = 20) goats during gestation and postpartum.

3.5.3. Body Weight of Kids at Birth

The average weight of kids at 2 h postpartum did not differ between those born to primiparous and multiparous ($p > 0.05$, Table 5).

Table 5. Weight and body temperatures (mean ± SEM) recorded 2 h after birth in kids born to primiparous and multiparous females.

	Multiparous n = 38	**Primiparous n = 15**	***p*-Value**
Weight at birth (kg)	2.9 ± 0.12	3.2 ± 0.20	0.263
Rectal temperature (°C)	39.3 ± 0.10	38.8 ± 0.35	0.233
Surface temperature (°C)	29.1 ± 0.80	30.7 ± 0.97	0.211

3.5.4. Internal and External Temperature of the Kids at Birth

Neither rectal (internal) nor surface temperatures recorded differed between goat's kids born to primiparous versus multiparous mothers ($p > 0.05$, Table 5).

3.5.5. Kids' Mortality Rate

The proportion of offspring that died during the first week postpartum was found to be no different between the primiparous (2/15) versus multiparous (6/32) groups, ($p > 0.05$).

4. Discussion

In this study of goats, the behavior of the dams in pre- and postpartum as well as the behavior of the offspring was influenced by the experience of the dams. However, progesterone and estradiol concentrations at the end of gestation were not affected by maternal experience. Therefore, our hypothesis that maternal experience is associated with maternal–kid behavior in peripartum and with the variations in circulating E2 and P4 levels could be partially supported. It is important to note that our work could be one of the first to evaluate the hormonal profile of progesterone and estradiol, and their relationship with behavioral and physiological indicators in the peripartum of goats.

The trophic behavior of periparturient goats has been sparsely researched, and to the best of our knowledge, there are almost no studies in which the role of maternal experience in this manner has been evaluated. Our study showed that females with previous births (multiparous) were less frequently observed eating and more inactive during prepartum, compared to females that were giving birth for the first time. These results coincide with those reported in multiparous dairy goats of the Norwegian breed, in which they observed that in the last third of gestation the occurrence of feeding behaviors was lower than in the first and second third of gestation [39]. These behavioral changes could be associated with the attitude shown by experienced females in this physiological stage, which modify their most important habits such as eating because they are more motivated to look for a place to give birth, to defend it and to avoid risks due to the presence of intruders as parturition becomes eminent, according to Lickliter (1985) [29]. Likewise, these behavioral changes could be due to the fact that there are differences in the strategies adopted by females to feed with the herd or to remain at the birthing site, as reported in previous studies on goats where it was observed that those multiparous females that decided to stay at the birthing site were older than three years in comparison to young females [40].

The results associated with feeding behavior found in our work also are similar to those displayed by camelids, where it was observed that primiparous mothers ate more than multiparous mothers, 12 h before giving birth [41]. In general, it has been reported that ungulate females at the end of gestation decrease the feed intake [42]. These results could indicate that inexperienced females try to perform more maintenance behaviors such as eating more, possibly because they have not reached their adult size since the growth of the uterus is smaller in primiparous females and there is more space to continue feeding as was reported in sheep [13,43]. The main mechanism behind the changes in feeding frequency at the end of gestation in primiparous mothers can be due to the smaller size of the uterus. Considering that in primiparous goats the uterus, among other tissues, is used for the first time—with less development, and given that primiparous mothers have a smaller uterus, it is possible that they indirectly have a greater filling capacity of the rumen [44,45]. This could also be in line with rumination behavior, as our results show that it was slightly higher in primiparous than in multiparous females, although there was no significant difference. Therefore, this study highlights that the maternal experience of goats affects feeding behavior prior to parturition, which could condition future responses to parturition in the mother-kid interaction. This study is an excipient but opens a path for further research to be carried out and to understand the relationship between behavior and development in female ruminants.

In addition to the differences in the feeding behavior, the maternal experience of the goats affected the activity behavior, since in the multiparous group there was a higher

frequency of females that were inactive compared to the primiparous group, this could be attributed to young females having more feeding episodes, as suggested by our results. Consequently, primiparous goats spend more time eating and being less inactive. In this sense, our study shows that locomotor activity is influenced by maternal experience, which was evidenced by a higher frequency of inactive behavior in multiparous goats in contrast to primiparous ones. These results of inactivity are different to those reported by Lidfors et al. [46], in which they observed that primiparous goats decreased their locomotor activity from 5 days prior to parturition, being more inactive than multiparous, even in the latter, locomotor activity began to decrease in the days prior to parturition [46]. Furthermore, the fact that primiparous goats are more active during pregnancy and parturition than multiparous goats could be linked to greater discomfort or stress. Similar results were found in dairy cows, where it was reported that during the 4 days prior to calving primiparous cows had a higher motion index (greater activity) than multiparous cows [42]. In multiparous dairy goats of the breed Norwegian, it was found that the movement distance in the last third of gestation is greater than in the first and second third of gestation, and it was also observed that the individual variation in the distance traveled was greater in the first than in the second third of pregnancy [39], therefore, in addition to maternal experience, locomotion activity can be affected by the stage of gestation. Therefore, factors such as experience and stage of gestation also affect locomotor behavior in goats.

Measurements taken during labor showed that the latency to lick the kid was affected by maternal experience, as it was considerably shorter in multiparous than in primiparous dams, confirming that maternal experience has immediate effects on maternal motivation, as reported by Lickliter [9] in goats, where he observed that when dams were separated immediately from their offspring at parturition, without any contact, and the amniotic fluid was removed from the offspring, it was found that after 2 h of reuniting dams and offspring, the cleaning latency was lower in multiparous than in primiparous goats. Similarly, our results are comparable to those reported in ewes, where it was found that first-lambing females took longer to initiate cleaning than multiparous females [12]. First-kidding females may experience neophobia and are apparently more affected by the pain of parturition, which causes them to lack immediate motivation to care for their newborn. Altogether, these results evidence that maternal experience in goats affected maternal behavior at parturition, suggesting that multiparous dams have a favorable behavior towards the offspring. It is important to clarify that in our study we found average values of cleaning latency above those reported in the literature, for example in a study carried out in well-fed goats a median of 4 s was reported, while in malnourished goats the average latency cleaning time was 7 s [47]. These studies, although they were carried out under similar conditions to ours, differ in the method of recording the behaviors, their analysis and duration of observation. Therefore, it is necessary to carry out more studies to confirm those found in the present work.

Despite this, the effects of early stimulation of the offspring were observed, since because the multiparous mothers began cleaning their offspring more quickly, the consequence was that a greater proportion of kids in this group rose in the first half hour of life and that they nursed in the first hour than the proportion of kids in the primiparous group. However, this difference in maternal behavior did not affect that of the kids, as not significant differences were found in the latencies to stand up and to suckle between the groups of primiparous and multiparous goats, although it was observed that the kids of primiparous females took slightly longer to perform these behaviors than those of multiparous females. This last result could possibly be attributed to the disparity in the sex ratio of the offspring, as multiparous goats had more male than female offspring, while primiparous goats had a similar number of male and female kids. According to what was described by Martinez et al. (2009) in primiparous goat's males and heavier kids were also slower to reach the udder, although in the end they recovered more quickly as they managed to suckle in the first hour [15]. In our case, we also carried out an analysis comparing the behavior of male and female goats without considering the parity of their mother and

we found no differences. Further studies are needed to clearly elucidate the factors that intersecting affect the behavior of goats.

As mentioned before, our results showed a high proportion of kids that got up before the first half hour and that were breastfed within the first hour after birth was higher in the multiparous group than in the primiparous group. Which coincide with those observed in dwarf goats from West Africa where it was found that kids born from single birth and from multiparous mothers suckled earlier than those born from primiparous mothers. Likewise, the multiparous goats showed greater vigor because they were groomed earlier than those of the primiparous [48]. In a previous study, it was found that goats born to well-nourished mothers had a waking time range of between 15 and 20 min, while those born to malnourished goats during pregnancy had a time range of between 19 and 42 min [47]. Therefore, the results in the present work in kids born from multiparous mothers are comparable to those obtained in well-fed goats, while those obtained in kids from primiparous mothers are comparable to what was obtained in malnourished goats, which suggests that possibly the physiological control of maternal behavior in inexperienced goats is more associated with the nutritional status of the animal. Although this hypothesis could be in contradiction with the result of the prepartum behavior in which we found that primiparous females were more frequently eating in the last three days before giving birth than multiparous females. The nutritional factor is important in these females because they are in development and as mentioned before the distribution of nutrients competes between those assigned to the development of the mother and those required to maintain the fetus. So, despite apparently eating more food, it is not enough to cover all the demands. We consider that the effect of nutrition is more important in the last 30 days of gestation where there are more demands for the development of the fetus. In our case, we only made behavioral observations in the last three days before giving birth. Therefore, it is necessary to conduct more research that relates trophic behavior, the nutritional status of the female and maternal experience during gestation on the mother-offspring bond. Also, our results are in line with other reports, as observed in females under a semi-extensive system with moderate malnutrition, where they found that suckling activity is lower in kids born from goats without supplementing compared to kids from goats supplemented with corn at the end of gestation [49].

In the case of maternal selectivity at 2 h postpartum, our results show that, in general, there is no difference between multiparous and primiparous goats, confirming that at this time, postpartum maternal selectivity is already established in this species [50]. Selectivity is considered the second stage of maternal behavior and is where it is determined that a mother has consolidated the imprint with her offspring and is ready to discriminate it from other offspring, to exclusively nurse its progeny and prevent others from feeding pups [51,52]. Our results coincide with those carried out in sheep of the breed Preálpes-du-Sud where they tested females of three parities: primiparous (with first birth), biparous (with two previous births and multiparous (with more than 3 previous births), it was found that there were no differences due to parity in the selectivity test [53]. However, in our study, inconsistencies were found in some behaviors in both groups, for example, in the primiparous group, the number of udder acceptances and the time near the udder tended to differ between own and foreign offspring, while in multiparous goats in both behaviors there were significative differences. These slight differences could be a consequence of the alterations observed during the first hours postpartum, since primiparous females took longer to begin grooming their offspring, compared to multiparous ones. In the same way, a lower percentage of kids born from primiparas stood up and reached the udder in the first hour of birth, compared to those from multiparas, which is an indication that the beginning of the maternal behavior called maternal responsiveness [52] it is affected by the mother's experience. While in the second phase where maternal selectivity is established [50], our results show that there may be slight failures in this stage on the part of inexperienced females. Previous work in goats has explored other factors such as the nutritional status of the female during pregnancy on the establishment of selectivity and

it was found that although the goats had nutritional deficiencies, selective behavior did not deteriorate, although it was affected the maternal responsiveness in the first hours postpartum [47,49]. Besides studies conducted in ewes show a higher tendency in udder acceptances in multiparous ewes towards own offspring than primiparous ewes [54], which leads us to believe that the mother's experience allows her to locate her kid faster and facilitating access to the udder [55]. On the other hand, our results are similar to those reported in Romanov sheep, where only multiparous females had a higher frequency of udder acceptances of their own than of the foreign offspring, which was not evident in primiparous females [56]. This suggests that as in sheep, maternal experience in goats affects selectivity. For the aggression category, we did not find a significant effect of maternal experience. However, in contrast to primiparous goats, we observed that multiparous goats had a higher frequency of aggression towards other goats' offsprings compared to their own offspring, suggesting that in this group offspring recognition was already fully established. As suggested by previous studies in goats and sheep testing only multiparous females [50,57].

Maternal birth weight was higher for multiparous than primiparous goats; it is important to remember that from the beginning of the experiment, multiparous females were almost two years larger than primiparous females and therefore also weighed more, so it was evident that we continued to find significant differences in the body weight of the goats between both parities throughout the study. However, our results coincides with what has been reported in Criollo goats by González-Stagnaro and Madrid-Bury [2], and by what has been reported in sheep where multiparous goats are heavier [13,58]. This can be explained because primiparous females are still developing at the time of the first gestation and they invest more energy and protein resources for the development of the fetus rather than for their body in comparison to multiparous females [13].

The weight of kids at birth showed no difference between the offspring of multiparous and primiparous mothers, which is in agreement with what has been reported in Creole goats [2] and in sheep [54]. Although the females had weight differences during gestation between primiparous and multiparous animals, this was not reflected in the weight of their kids, nor in the body temperature, since the offspring of both groups had similar values in these variables; this could be associated with the fact that the nutritional reserves were directed towards the growth of the fetus. In addition, it is related to the results obtained in the body condition (CC) of the mothers since it was observed that it was similar, which denotes that the nutritional status was adequate, since the CC was maintained for both groups during gestation above 2.5 points. These results contrast with the behavioral differences observed between both groups. For example, we found higher latencies for grooming the kids in primiparous goats, which could have affected the speed with which the kids stood up, since in this group there was a lower percentage of kids standing in the first half hour of life and a lower percentage of kids that were nursing in the first hour after birth, compared to the kids of multiparous females. On the other hand, despite these effects, the survival rate was not altered, since the mortality rate in the first 7 days after birth was lower and similar for both groups (primiparous 2/15 and multiparous 6/32).

With respect to plasma concentrations of progesterone and estradiol, we found no differences according to maternal experience, which is consistent with that reported in sheep [12,59]. Meurisse et al. reported in ewes that no difference was found in progesterone and estradiol concentrations according to maternal experience [59]. These results makes us think that the differences in the presentation of behaviors but not in the plasma profiles of progesterone and estradiol in our study could be related to the lower sensitivity of primiparous goats to the preparatory action of estradiol in the brain regions associated with maternal behavior, as it occurs in sheep [12], or to the activation of the olfactory system for the recognition of the offspring, again as it occurs in sheep [52]. However, in goats there is no published evidence in this regard, so further studies are needed. Beyond the possible mechanisms that could be involved in sensitivity at brain level between primiparous and multiparous goats, this study shows that changes in the behavior of goats according to

parity during peripartum do not seem to be linked to the profile of changes in plasma concentrations of progesterone and/or estradiol.

5. Conclusions

Maternal experience affected some behavior of goats during the peripartum period, which was evidenced by a greater frequency of eating and less inactivity in primiparous than in multiparous goats. Primiparous goats take longer to care for their offspring after their expulsion which could have affected the speed with which the kids stood up, since in this group there was a lower percentage of kids standing in the first half hour of life and a lower percentage of kids that were nursing in the first hour after birth, compared to the kids of multiparous females, so it is necessary to pay more attention to females without maternal experience. Although in general the establishment of maternal selectivity is similar between females of both parities, primiparous do not show a clear consistency in all behaviors of acceptance of their offspring or the rejection of the foreign kid. Despite the differences found between primiparous and multiparous before and after kidding, no changes were observed in progesterone and estradiol concentrations due to maternal experience, so these behavioral differences could be related to other factors.

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Informed Consent Statement: Not applicable since animals were used in this study and no humans were involved.

Data Availability Statement: The data used in the study will be made available to other researchers on request.

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