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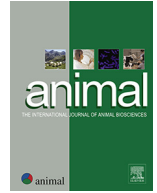
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Dam parity and calf sex affect maternal and neonatal behaviors during the first week *postpartum* in stabled Maghrebi dairy camels



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ABSTRACT

Currently, a trend toward the commercialization of dromedary milk associated with recent intensive rearing systems has starting worldwide which impose constraints on animals affecting their behavioral repertoires and welfare status. The aim of this study was to investigate the effects of dam parity and calf sex on parturition, neonatal, and maternal behaviors in stabled Maghrebi dairy camels (*Camelus dromedarius*). Thirty-six (primiparas $N = 10$; multiparas $N = 26$) periparturient females were kept under video surveillance using a digital IR camera and 24-h sessions were chosen to assess calving, maternal, and neonatal behaviors in calving pens. Duration of restlessness, process of giving birth, and expulsion of fetal membranes were assessed. After first suckling, dams and their calves were moved into an individual enclosure to assess maternal behavior at 12 h, 24 h, 48 h, 72 h, and 7 d *postpartum*. Behavior was assessed using a camcorder for 30 min after 1 h of young separation in an adjacent enclosure. Results showed an effect of parity on the duration of the birth process which was longer for primiparous than multiparous camels ($P = 0.034$). During this stage, primiparous females tended to raise their tails more often ($P = 0.054$) and spent more time standing ($P = 0.001$) than multiparous camels. Neonatal behavior was affected by calf sex. Female newborns took less time to raise their heads ($P = 0.041$) and to stand up ($P = 0.048$) for the first time and were the earliest to suckle their dams ($P = 0.032$). Multiparous dams stood up sooner ($P = 0.019$) after calving and suckled their calves earlier ($P = 0.043$) than primiparous dams. They emitted more bleats and exhibited more sniffing during the first week *postpartum* than primiparas. During the first *postpartum* week, both primiparas and multiparas showed a decrease in the total number of bleats ($P < 0.001$), low-pitch bleats ($P < 0.001$), and high-pitch bleats ($P < 0.001$), in sniffing frequency ($P < 0.001$) and sniffing duration ($P < 0.001$). This is the first study to describe in detail the calving, maternal, and neonatal behaviors of dromedary camels and to show the influence of parity and calf sex. Maternal care toward the newborn calf exhibited by a high level of bleating and sniffing activities in the first 2 days suggest that they play an important role in the establishment of mother–young relationship.

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Implications

Intensification systems for camel milk production could impair maternal behavior and better establishment of the mother–young relationship. During parturition, multiparas chose to lay down unlike primiparas spent more time in standing position. Camel newborns took lot of time to suckle. Multiparas succeeded in nursing their calves earlier and female calves took less time to express their neonatal

activities. Vocal and sniffing behaviors of the mother were more frequent during the first 2 days *postpartum*. Breeders do not bothered about delaying of first suckling but should provide particular care for primiparas to ensure calf development and survival especially in males.

Introduction

Camels (*Camelus dromedarius*) are reared under extensive conditions in the arid and desert lands where they spend most of the day walking and feeding mostly on dry grasses, foliage, and desert vegetation (Abdel Fattah and Roushdy, 2016). Currently, a trend toward the

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commercialization of dromedary milk associated with recent intensive rearing systems has starting worldwide using machine milking (Hammadi et al., 2010). Consequently, dromedary females are kept indoors for several months including the late pregnancy and early lactation periods. Such practices can affect adequate development of mother–young bonding during the crucial period after birth and may be decisive for breeding profitability. This is a critical point since maintenance of lactation and milk let down in this species rely on the presence of the young with its mother during 12 months of the lactation period (Hammadi et al., 2010). In addition, intensive management imposes constraints on the animal (e.g., limited space, frequent human handling, social disturbance etc.) that could affect its behavioral repertoire and welfare status. In cattle, parturition can be affected by human interference (Barrier et al., 2012), and this might be the case in camels.

Parturition is well documented as a challenging process, a high-risk time and stressful event both for the mother and her offspring (Nowak et al., 2000), which represents a crucial step in animal husbandry. In mammals, preferential maternal care is important to promote investment by the mother in her progeny, especially in social species. Fundamental roles of mothers are nursing, defending the neonate, and influencing the development of social and feeding behavior in their offspring. In almost all ruminants, maternal behavior includes a set of behaviors expressed during late gestation (e.g., seeking an isolated place to give birth) and lactation (e.g., nursing, vocalizing, and defending the litter) that shapes bonding and improves offspring survival (Dwyer et al., 2016). In fact, chances of survival beyond the first few weeks of life are highly related to maternal care and infant behavior ensuring colostrum intake and passive immunity transfer. Maternal behavior, expressed particularly during nursing, is displayed intensively immediately after parturition and generally fades with aging of the offspring. The rapidity of the onset and the quality of maternal care contribute to the motivation and success of the newborn in performing neonatal behaviors (Dwyer and Lawrence, 2005).

Several studies in ruminants reveal that the mother–young relationship improves with parity, as shown by differences in spontaneous behavior and in the response to separation challenges (Poindron et al., 2007).

In the first hours after parturition, primiparous dairy cows express a higher incidence of maternal aggressiveness and rejection of the calf (Dwyer, 2003). Multiparous beef cows have a stronger behavioral response to brief temporary calf separation and upon reunion than primiparas (Price et al., 1986). The sex of the newborn is also a factor likely to shape early behaviors and then survival through early interactions with the mother and colostrum intake. Female foals stand up earlier after birth than males (Campitelli et al., 1982). Female lambs stand and suckle sooner, and follow the mother more closely (Plush, 2014). However, such differences may not extend to all ruminants since in Surti buffalo's sex was not observed to influence neonatal and maternal behaviors (Dubey et al., 2018).

While mother–young interactions are particularly well known in ruminants such as sheep, goats, and cattle (reviewed in: Poindron et al., 2007; Miranda-de la Lama and Mattiello, 2010; Nowak et al., 2011), such behavioral aspects have been very poorly investigated in dromedaries. Only behavioral peculiarities have been briefly cited like the lack of licking at calving (Long, 2007), or allosuckling performed by opportunistic calves (Brandlová et al., 2013). The aim of this study is to provide the first thorough description of neonatal and maternal behavior traits in Maghrebi dromedary camels during the first 7 days *postpartum* in stabled conditions. Two factors were taken into consideration: parity of mothers and sex of the calves. Like in the majority of ruminants, we hypothesized that *postpartum* behavior would improve with maternal experience and female calves would display neonatal activities more rapidly than males.

Material and methods

Site, animals, and management

This study took place at the experimental station of Institut des Régions Arides de Médenine, located in the southeast of Tunisia (33° 30' N latitude, 10° 40' E longitude) with an elevation of 18 m above sea level. This region has an arid Mediterranean climate with an annual average temperature and rainfall of 19 °C and 180 mm, respectively.

Thirty-six pregnant dromedary females (10 primiparas: weighing 419 ± 30 kg, aged 6.1 ± 1.0 years and 26 multiparas: weighing 460 ±

Table 1
Description of calving, neonatal, and maternal behaviors in Maghrebi dromedary camels.

Behaviors	Description and measurement
Calving behaviors	
Parturition	
First stage	Period (min) from the evidence of discomfort and restlessness until the first water bag appears at the vulva
Second stage	Latency (min) from the appearance of the amniotic sac to the total expulsion of calf (parturition)
Third stage	Period (min) from the birth of the calf until the fetal membranes are expelled
Placentophagia (yes/no)	Consuming part or all of the afterbirth following parturition
Positions during the second stage	
Lying	Female lies on the ground Duration (s) of lying position adopted by camels
Standing	Duration (s) of position in which camels stand upright on all four legs
Changing position	Frequency of alternation between lying and standing
Tail raising (no. of bout)	The number of tail movements during the second stage of parturition
Neonatal behaviors	
Raising head (s)	Raises the head just after birth while lying
Onto knees (min)	Calf on chest, pushing up on knees and supporting part of body on the ground
Standing up for the first time (h)	Upright on all four legs fully extended for the first time for at least 5 s
Search the udder (h)	Stands in parallel reverse position, with its head in udder region
Suckling for the first time (h)	Has teat in the mouth and appears to be suckling for at least 10 s
Maternal behaviors	
First standing (s)	The latency from the total expulsion of calf to the first stand up and return to her neonate
Bleats frequency	
Total bleats	Any sound emitted with the mouth
Low-pitched bleats	The number of quiet vocalizations emitted with the mouth closed
High-pitched bleats	The number of loud calls emitted with the mouth open
Sniffing frequency/duration (s)	The number/duration of contacts between the mother's nose and the newborn
Licking (yes/no)	Mother licking the newborn
Orient the neonate to the udder (yes/no)	Mother pushing the newborn with her head toward the udder

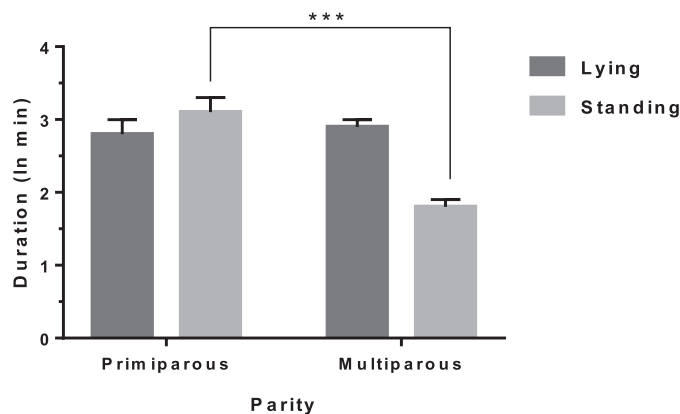


Fig. 1. Effect of parity on the duration of lying and standing positions (ln min) during the second stage of parturition in Maghrebi dromedary camels. ***: $P < 0.001$.

47 kg, aged 14.5 ± 4.0 years) and their newborn calves were investigated during the Tunisian calving season from October to April. As the gestation period in camels is 384.8 ± 14.0 days (Hammadi et al., 2001), during the first 10 months of gestation, females were kept indoors at night and moved outdoors during the day to spend 6–7 h grazing salty native plant species. Approximately 2 months before the expected calving date, females were kept indoors and gathered in 5–7 animals/group in a common enclosure (70 m²). The food intake per animal was composed of 4.4 kg barley straw (DM, 88.8%; CP, 5.6%; NDF, 70.3%; ash, 10.4), 2.2 kg olive cakes (DM, 87.2%; CP, 8.1%; NDF, 42.4%; ash, 4.6), and 2.2 kg concentrate (DM, 87.8%; CP, 11.8%; NDF, 38.2%; ash, 8.9). Females were taken to the water trough once a day located outside their enclosure since, being adapted to desert conditions, dromedaries do not need ad libitum access to water.

Maternal and neonatal behaviors in the calving enclosure

Dams were kept under 24-h video surveillance in the calving enclosure using a digital IR camera (DAHUA – HAC-HDW1220M) placed at the corner of the common enclosure and 24-h sessions were chosen to assess the periparturient and neonatal behaviors from birth to first suckling. In parallel, maternal behaviors during the first hour *postpartum* were videotaped for 30 min using a camcorder (Sony® X60). An ethogram was defined to code and measure specific behaviors (Table 1). Parturition was subdivided into three stages for a detailed analysis of the process: restlessness, process of giving birth, and expulsion of fetal membranes (Titler et al., 2015).

Maternal behavior assessment following a separation-reunion test

After the first suckling, dams and their calves were moved into an individual 15 m² enclosure. To stimulate behavioral interactions, the calf was separated from the mother for 1 h and placed in an adjacent enclosure (2.2 × 2.1 m) allowing visual and auditory communication. Maternal behavior was then videotaped for 30 min using a camcorder (Sony® X60). To assess the change in maternal behavior (i.e., the number of bleats and sniffing the newborn) the test was repeated at 12 h, 24 h, 48 h, 72 h,

and 7 d *postpartum*. Behavioral data were analyzed by one expert person using Boris software 6.3.1 (Friard and Gamba, 2016).

Statistical analysis

All statistical analyses were performed using Statistical Analysis Systems Institute (2012). Variables relating to calving (durations of first, second, and third stage of parturition, posture at calving (lying and standing), changing position and tail raising, and latency to first standing) were analyzed using the PROC mixed model. Normality was verified using Shapiro–Wilk test and, except for tail raising, all the above variables were transformed by Napierian logarithm function. A preliminary analysis that included parity, sex, and calving period (period 1: October–January, period 2: February–April) as independent variables did not show any significant effect of calf sex and calving period, so the chosen PROC mixed model included only the general mean, parity as the fixed variable, and camel identity and residual error as the random variables. All given estimates are presented as ln-transformed least squares means (LSM) ± standard errors (SE), whereas back-transformed LSM values are given in the text and in Table S1 of the Supplementary Material. Tail raising results are presented as LSM ± SE. P -values are considered significant at <0.05 and tendencies at <0.06 .

Calf behavioral data remained non-normally distributed after transformation (Shapiro–Wilk test); therefore, the effect parity and sex of calf was studied using Mann–Whitney tests. P -values less than 0.05 were considered as statistically significant and results are presented as medians and lower and upper quartiles (LQ–HQ).

Maternal behaviors (total number of bleats, high-pitched bleats, low-pitched bleats, sniffing duration, and sniffing frequency) data were analyzed with PROC GLIMMIX using log link for Poisson data. The model included the general mean, calf age, calf sex, mother parity, parity*age and the sex*age interactions as the fixed variables, and camel identity and residual error as the random variables. All given estimates are presented as ln-transformed least squares means (LSM) ± standard errors (SE), whereas back-transformed values of dependent variables are presented in Tables S2 and S3 of the Supplementary Material.

Results

Maternal behavior at calving

The three stages of parturition, restlessness, process of giving birth, and expulsion of fetal membranes lasted 432 ± 42 , 33.8 ± 2.2 , and 80.2 ± 12.6 min, respectively. No effect of parity on the first and the third stages was found. On the other hand, the duration of the second stage was longer ($P = 0.034$) in primiparous than in multiparous

Table 2

Neonatal behaviors (median, [lower quartile – upper quartile] and minimum and maximum) in Maghrebi dromedary calves at birth.

Behavioral event	Median	[25 – 75%]	[Min – Max]
Raising head (s)	3.6	[2.0–12.7]	[1.0–53.0]
Onto knees (min)	5.1	[3.0–6.9]	[0.2–20.0]
First stand up (h)	3.3	[2.4–4.0]	[0.8–5.8]
Searching for the udder (h)	3.5	[2.9–4.4]	[0.9–6.8]
First suckling (h)	5.6	[4.8–7.3]	[1.1–12.7]

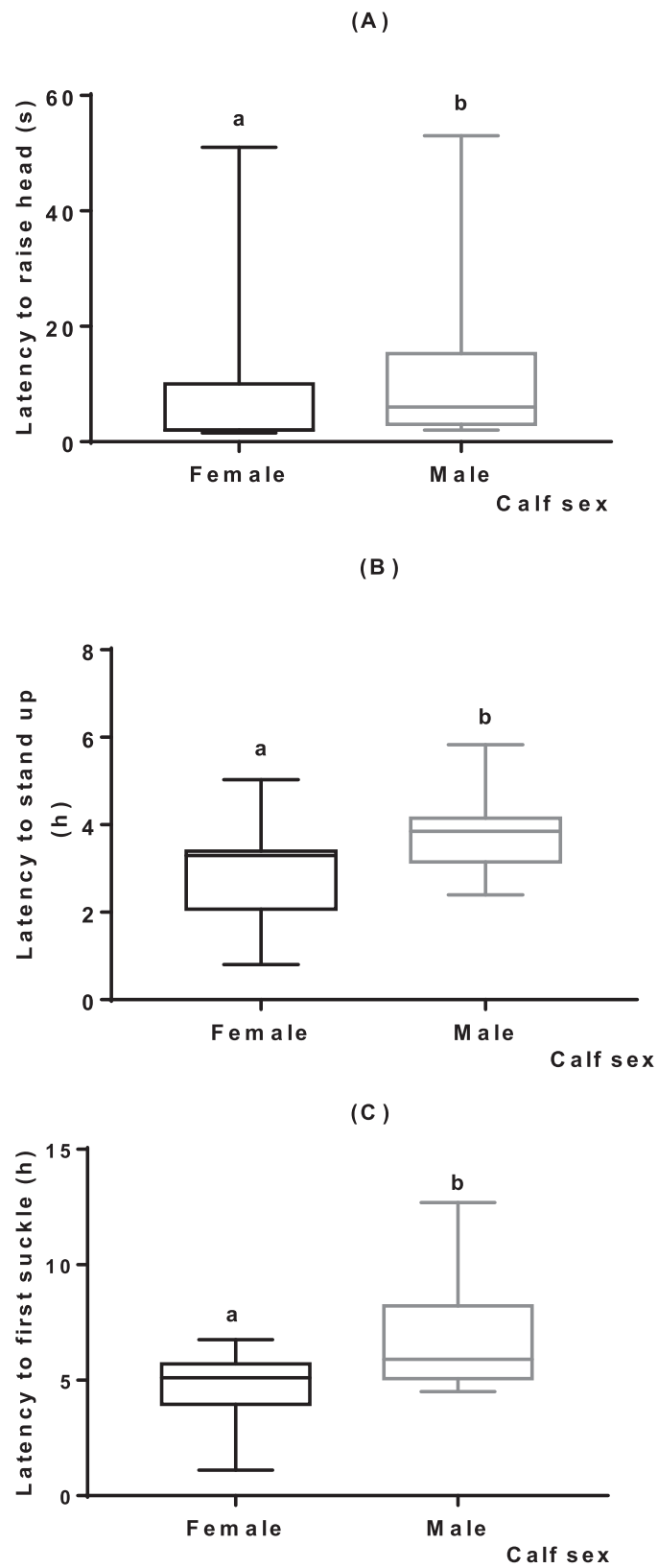


Fig. 2. Effect of calf sex on neonatal behavior in Maghrebi dromedary camels. (A): latency to raise the head, (B): latency to stand up (C): latency to suck. Values are medians (bar within the box), upper and lower quartiles (boarders of box) and the upper and lower whiskers represent scores outside the middle 50%. a vs b: $P < 0.05$.

females (3.7 ± 0.1 vs 3.4 ± 0.1 min, respectively); back-transformed mean values were 40.4 min for primiparous camels and 29.9 min for multiparous camels.

Tail raising occurred 30.3 ± 3.0 times during the second stage with a tendency to be more frequent in primiparous than multiparous females (40.4 ± 4.9 vs 25.5 ± 3.3 times, respectively, $P = 0.054$).

The second stage was also characterized by alternations of lying and standing positions, which averaged 4.6 ± 0.5 times. Primiparas changed positions significantly more than multiparous mothers (2.1 ± 0.1 vs 1.5 ± 0.1 times, respectively, $P = 0.002$); back-transformed mean values were 8.1 times for primiparous camels and 4.4 times for multiparous camels.

Lying and standing durations averaged 19.3 ± 1.6 and 13.9 ± 2.1 min. The time spent in lying position was not affected by parity, while primiparous spent more time ($P < 0.001$) in standing position than multiparous mothers (Fig. 1).

Behavior of the newborn dromedary

The first behavioral activities of the calf are illustrated in Table 2. Newborn dromedaries shook their heads 3.6 s (2.0–12.7) after birth and attempted to stand up pushing onto their knees within 5.1 min (3.0–6.9).

An important variability in the expression of neonatal behaviors was observed; some calves took an hour or less to stand up and suckle successfully, while others needed several hours (Table 2). This variability resulted from a combined effect of sex of calves and parity of mothers. Female calves took less time to raise their heads (Mann–Whitney test, $U = 52.0$, $P = 0.041$, Fig. 2A), to stand up (Mann–Whitney test, $U = 48.0$, $P = 0.048$, Fig. 2B), and to suckle their mothers (Mann–Whitney test, $U = 29.0$, $P = 0.032$, Fig. 2C).

In parallel, parity of the dam affected significantly the latency to suckle for the first time. Calves born from multiparas suckled their mothers earlier than calves from primiparas (Mann–Whitney test, $U = 22.0$, $P = 0.043$; 5.1 h [4.6–5.8] vs 7.1 h [5.7–8.6], respectively).

Maternal behavior after calving

Mothers stood up soon after delivery (46.0 ± 13.4 s) and by doing so ruptured the umbilical cord. They oriented toward the neonate, sniffing it, and vocalizing. Interestingly, licking and placentophagia were never observed. After the calf was standing steadily, 20 from 26 multiparous mothers tended to orient their neonates to find the teat by pushing them with their heads toward the udder. This behavior was not observed in primiparous mothers.

Mothers displayed frequent sniffing episodes of short durations in the first hour. They were also quite vocal with two types of bleats emitted: low-pitched (with the mouth closed) and high-pitched bleats (with the mouth open). Other aspects of maternal behavior changed during the first week. A significant decrease was revealed in the total number of bleats ($P < 0.001$), low-pitched bleats ($P < 0.001$), and high-pitched bleats ($P < 0.001$), as well as in sniffing frequency and duration ($P < 0.001$ in both cases). Parity had a major influence on maternal behavior. After calving, multiparous dams stood up sooner than primiparous dams (2.2 ± 0.3 vs 4.5 ± 0.8 s, respectively; $P = 0.013$; back-transformed mean values were 9.0 s for multiparous and 90.0 s for primiparous camels).

Total numbers of bleats and low-pitched bleats, sniffing frequency, and duration decreased significantly during the first week for both parity. Overall, multipara exhibit significantly more total bleats, low-

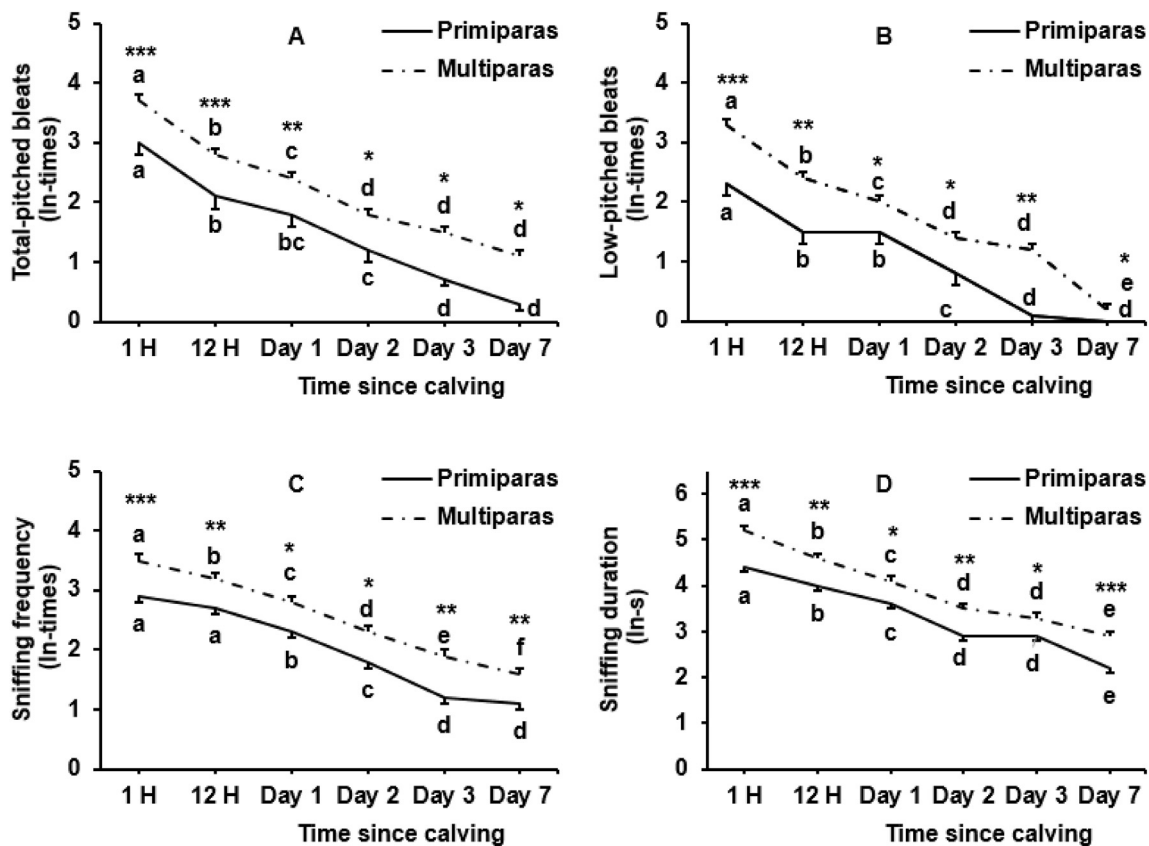


Fig. 3. Effect of parity on the number of total bleats (A), the number of low-pitched bleats (B), sniffing frequency (C), and sniffing duration (D) in Maghrebi dromedary camel mothers during the first week *postpartum*. For each time point, difference between parities is significant at: * $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$. a–f: for each parity, difference between time points is significant at $P = 0.05$.

pitched bleats, sniffing frequency, and duration than primiparous mothers (Fig. 3A–D).

Calf sex affected total number of bleats, high-pitched bleats, and sniffing duration (Fig. 4A–C). The expression of these three behavioral activities declined significantly with calf age during the first week.

Discussion

This is the first study describing in detail the parturition process in stable primiparous and multiparous camels, and the change in maternal and neonatal behaviors during the first week *postpartum*. The present study shows that parity of dams and calf sex influenced maternal and neonatal behaviors. Multiparous mothers laid down during most of the calving process while primiparas spent more time standing and laid occasionally, in particular during the last stage of calf expulsion. They also succeeded in nursing their calves earlier. Vocal activity and sniffing behavior of the mother were more frequent during the first 2 days after parturition, which suggests that this is a crucial period for proper establishment of the mother–young relationship.

The process of giving birth is the most stressful and painful stage of parturition, hence the females changing positions frequently from lying to standing. Our study showed that this stage was longer in primiparous than in multiparous camels. In general, primiparous females take longer to expel the fetus. This was reported in cattle (Norman and Youngquist, 2007) and in goats (Das and Tomer, 1997), while the differences are less pronounced in sheep depending on the breed (Dwyer, 2003). A significant increase in tail movements was detected when dromedaries were giving birth. Tail movements are related to fetal kinesis or uterine contractions. Our study shows that they were more frequent in primiparous camels that are likely to exhibit pain more strenuously. Such signs of restlessness and discomfort could be useful tools to monitor parturition in primiparous camels in order to give proper assistance when needed. Cervix of multiparous mothers was more malleable because they had already experienced parturition, thus facilitating the expulsion of the fetus and reducing the signs of acute stress (Abdela and Ahmed, 2016).

Camels laid down and stood up frequently until total expulsion of the calf. Primiparous camels spent more time standing compared to multiparous camels, meaning that they were more restless. Postural changes from lying to standing have also been reported in bovine species (Miedema et al., 2011). More importantly, pain and discomfort in parturient primiparas could cause it when the calf was passing through the birth canal. Multiparous mothers may have adopted the lying position as they were less stressed by parturition and such a posture may be more comfortable to expel the fetus.

The third stage of parturition which involved the expulsion of the fetal membranes and the placenta lasted more than 1 hour. It was characterized by straining postures every 2–3 min, the mother rolling on the ground – resting – and rolling again before standing up before full expulsion of the placenta (Musa and Merkt, 1990).

Interestingly, camel mothers did not lick their neonates, also placentophagia was never observed. Only a few species do not lick their neonates after parturition among which are found suids, pinnipeds (Gonzalez-Mariscal and Poindron, 2002), and camelids (e.g., Llamas: Sumar, 1999). The lack of licking in these species is not understood since the benefit is to clean and dry up the young, provide tactile stimulations that influences neonatal behavior, and favor in particular the learning of olfactory cues. These are obviously not necessary in camelids. Placentophagia is less common than licking among ungulates but again the reason why it is seen in some species and not in others is unknown (Kristal, 1980).

Our study reveals that camel calf behaviors differ from those displayed by species of similar size or morphology. The latencies to raise the head and push up onto the knees were shorter than those observed in giraffe (Kristal and Noonan, 1979) and bovine calves

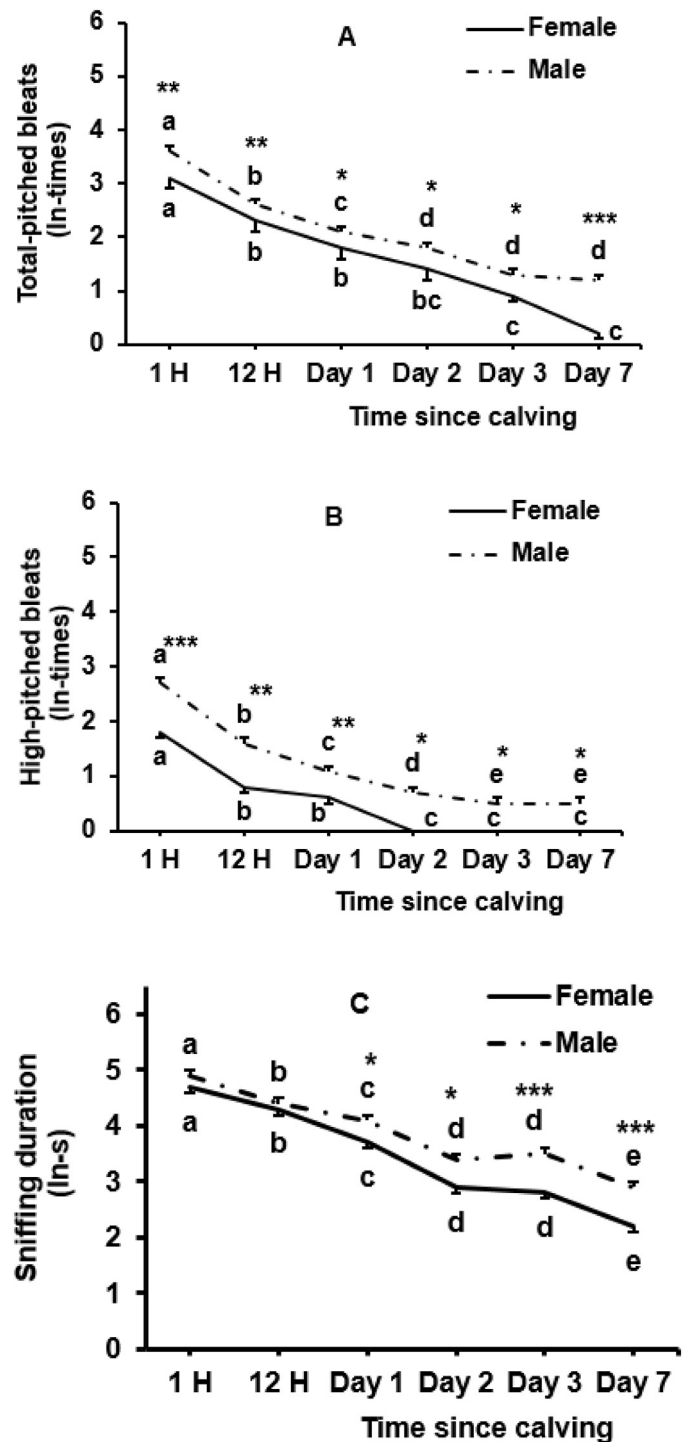


Fig. 4. Effect of calf sex on the number of total bleats (A), the number of high-pitched bleats (B), and sniffing duration (C) in Maghrebi dromedary camel mothers during the first week *postpartum*. For each time point, difference between sex is significant at: * $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$. a–e: for each sex, difference between time points is significant at $P = 0.05$.

(Christine et al., 2015). However, camel calves need more time to stand up, search the udder, and suckle comparably to llama (Tibary et al., 2014), rhinoceros (Plair et al., 2011), and giraffe calves (Kristal and Noonan, 1979). Even though camel mothers help their neonates to find the teat by pushing them with their snouts, camel calves take longer to achieve suckling for the first time. This needs to be confirmed and make sure that it is not related to our herd, strain, or rearing

conditions. On the other hand, the difference between camel newborns and newborns from other species could also be attributed to a particular morphology, since long limbs and neck along with a slightly curved back characterize this species making standing up a particularly hard task. Moreover, the female camel displays passive maternal behavior since she does not lick her newborn which must rapidly raise and shake its head, get rid of fetal membranes from its muzzle, and be able to breath steadily. The lack of licking behavior, which dries and stimulates the newborn, may slow down neonatal activities. It is a traditional and common practice that dromedary camel stockholders tap the hind legs of the newborn to motivate it to stand up and suckle as soon as possible (Pr Hammadi, personnel communication).

The influence of sex on neonatal behavior deserves particular attention. In our findings, dromedary female calves were faster than males in raising their heads, standing up, and suckling. In sheep, females are more vigorous than males, and the latter are subjected to longer labor affecting the time to stand and to suckle (Plush, 2014). One explanation is in the lower BW of female compared to male lambs that would facilitate the birth process (Dwyer, 2003). We did not weigh the calves at birth and this should be done in future work. Such sex differences in locomotor activities may also exist before birth suggesting a relationship between fetal kinesis and neonatal behaviors (Plush, 2014).

Our findings showed that multiparas succeeded in nursing their newborns sooner than primiparas. Primiparous mothers had no past maternal experience and moved away from their calves as they approached the udder. In dairy cows, failure in heifers to nurse their calves is linked with maternal threat and butting, which is rare in multiparous mothers (Edwards, 1983). Immediately after parturition, the dromedary mother stand up and turns toward her neonate, which appears to be under the influence of mothers' parity. In our findings, multiparous camels stood up sooner and exhibited more bleats and sniffing compared to primiparas, which could be related to the shorter duration of the expulsion process. In bovine species, primiparous cows have more calving difficulties; this explains the delay to stand up and display maternal care compared to multiparous mothers (Meyer et al., 2001).

Low- and high-pitch bleats are two types of maternal vocalizations differing in acoustic structures and diversely emitted by camels. During the early hours of contact, mothers emitted mainly low-pitched bleats indicating the onset of maternal behavior and newborn acceptance like in sheep (Nowak et al., 2011). At the same time, the number of high-pitch bleats was higher in the first hour *postpartum*. This may appear unexpected since in sheep high-pitched bleats are not frequent around parturition (Sèbe et al., 2007). This may be a feature of camel maternal behavior reflecting a motivational state around parturition and/or signs of disturbance due to our experimental situation. The fact that the number of high-pitched bleats declines over time supports both hypothesis. As mother–young vocal communication has never been described in camels, this should be thoroughly investigated in future research.

Vocalizations and sniffing are of special interest as they favor mother–young interactions and the possibility to learn each other's identity through vocal and chemical communication (Lévy et al., 2004). This provides optimal ground for the development of multisensory recognition between mother and young. Maternal sniffing activity was influenced by the gender of their newborns. In our study, from the 1st to the 7th day after birth male calves were sniffed more frequently than female calves. Similar results were found in beef cattle (Stěhulová et al., 2013). It may be that, like in rodents (Lévy et al., 2004), male neonates emit chemical signals that are more attractive than females.

Conclusion

Maternal attention toward the newborn calf sustained by a high level of bleating and sniffing activities in the first 2 days suggest that they play an important role in the establishment of mother–young relationship. The delay in the expression of neonatal behaviors, especially

suckling, was rather unexpected and deserves some attention. In addition, significant influence of parity and calf sex were observed on maternal and neonate behaviors. This work opens the way for further studies to better understand behavioral and physiological mechanisms involved in the establishment of mother–young relationships in Maghrebi dairy camels. Future work should explore the dynamic of recognition between the two partners and the sensory cues involved. For instance, the fact that mothers do not lick their calf is rare in mammalian species and raises the question of what mechanisms involved in recognition are at play. In addition, the mechanisms by which the neonate is guided to find the teat and suckle which appears to take time in this species would be of interest to find out if it influences its survival both under intensive and extensive rearing.

Supplementary materials

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.animal.2020.100149>.

Ethics approval

The experimental conditions of the present work complied with the European Directive 2010/63/EU on the protection of animals used for scientific purposes.

Data and model availability statement

None of the data were deposited in an official repository.

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Declaration of interest

The authors declare that they have no conflicts of interest.

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