Imprinting, Sucking and Allosucking Behaviors in Buffalo Calves

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Abstract: This paper provides a short review of the scientific literature, focusing on recent advances on the most representative events from birth to weaning, with special emphasis on the behavior and welfare of buffalo calves during the phases of imprinting, suckling and allosucking, based on the differences and similarities reported with dairy and beef cattle. The similarities include the facts that all 3 are gregarious animals whose dams separate from the herd prior to parturition to facilitate dam-calf bonding, and that maternal care fosters the ingestion of colostrum by the young. These species are also precocial and rely on mother – young mutual recognition for calf survival. In particular, mothers develop a selective bonding with their young soon after parturition, although buffalo cows seem to be tolerant to alien claves and are often engaged in communal nursing. In buffaloes and cattle negative emotions are induced by the stress brought on by early maternal separation. However, buffalo calves are more prone to express cross-sucking and contract neonatal diseases with higher mortality rates in intensive systems as compared to cattle. The review concludes that all three exhibit similar behaviors from parturition to weaning although the knowledge about the specific needs of buffalo calves should be increased and appropriate management practices implemented to improve their welfare state.

Keywords: Cow-calf bonding, calving, dam-calf bonding, buffalo calves, dairy calves, beef cattle calves, welfare, suckling behaviour, allosuckling.

INTRODUCTION

The increase in the global demand for animal products in the last decades of the twentieth century has induced a remarkable intensification of rearing techniques, replacing the traditional systems. This intensification can negatively affect the welfare of animals by modifying the environmental conditions (confinement, feeding, etc.). More specifically, the intensification can cause welfare problems if the animals cannot adequately perform social and innate behaviors [1-5].

Practices like early artificial rearing generate stress in cows and calves, as under some systems, dairy calves are not allowed to suckle at all [6].

In mammals the altricial–precocial dichotomy may explain some of the interspecific variation in the expression of the social interactions between mother and her young and in the development of their bonding. In precocial mammals, the offspring require limited parental care and are relatively mature and mobile and can forage independently while still being nursed (mostly ungulates, e.g. buffaloes, cows, sheep, goats, horses, deer) [7, 8].

In precocial species the survival and performance of neonates soon after birth are based on reciprocal recognition. For parents, recognizing their own offspring prevents misdirected parental care, whereas newborn precocial animals need to stay in close contact with the mothers to receive food and protection. Therefore, establishing a close dam-offspring relationship at an early post-partum phase is essential [9, 10].

In contrast in altricial species, the mothers give care (licking, nursing) to all young that are inside the nest, even if they belong to another mother, whereas in species giving birth to precocial young, the mother

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does not usually build a nest, but instead, develops an exclusive relationship with their young [8, 11].

In buffaloes a long-lasting cow-calf bond develops soon after birth, a relationship promoted by two principle mechanisms: the mother's maternal behaviour and the neonate's capacity for learning [2].

For parents of precocial species, offspring recognition limits energy expenditures and increases reproductive success. From the perspective of the offspring, recognizing their parents is essential for their welfare and survival, since the dams of precocial species feed only their own young [9]. This learning process, defined as imprinting, occurs in a sensitive period under the control of oestrogens and oxytocin, which are abundantly produced at parturition. After few hours the level of these hormones lowers and dams become unable to develop an appropriate maternal behaviour towards the newborn calves [4, 10, 12, 13].

The onset of maternal behaviors is propelled by a combination of factors that include neuronal, humoral and sensory elements, it is designed to lead the dam to feed and care for her progeny by performing a range of behavioral patterns whose purpose is to promote the vitality of the neonate [4, 8, 14, 15].

The buffalo dam and others ruminant mothers acquire the ability to recognize their own young rapidly, and reject any alien neonate that attempt to suckle. In sheep and goats, this discrimination is established within 2–4 h after birth [5, 10, 16, 17]. The amniotic fluid that covers the neonate is attractive for mothers and, while licking the newborn, they learn its specific odor thus promoting the development of a selective mother–young bond, whereas the lack of amniotic fluid may cause rejection of the newborn [4, 5, 8, 15].

The most important aspect of the birth process is that calves must quickly locate the udder and begin to suck their mothers' milk. This is because suckling and the maternal care that calves receive allow them to survive and grow for productive development [4, 18, 19].

The health status of the calf at birth is difficult to assess, and even more challenging is to predict outcomes such as poor performance and pre-weaning mortality [15, 20, 21].

Vitality scores have been widely used by researchers to identify and quantify the risk factors associated with morbidity and mortality in calves during the perinatal and neonatal periods [15, 21, 22].

In the majority of mammals, the female dedicates a high level of energy to the offspring during a period of high maternal motivation. This period of investment is followed by natural weaning, which involves a gradual reduction of the milk quantity supplied by the mother to the calf [8], or early abrupt weaning in intensive systems. In these systems buffalo calves show higher mortality rates as compared with dairy and beef cattle [23].

However, when it comes to the behavior of un-weaned buffalo calves, we find very few studies. For this reason, the objective of this article is to review and integrate information on the most representative events in calves from birth to weaning, including imprinting, suckling and allosucking, by describing differences and similarities with those reported for dairy and beef cattle and comparing them to the conditions that will best ensure the welfare of buffalo calves.

IMPRINTING

Although the English naturalist D.A. Spalding in 1873 [24] and the American psychologist W. James in 1887 [25], spoke and experimented about sensitive periods and instinct at the early stage after birth, it was the Austrian zoologist and ethologist Konrad Lorenz who postulated a critical period in the filial bond which he called "Prägung", that was translated into English as "imprinting" [26,27]. Lorenz coined the term "imprinting" to refer to the trace that remains in the brains of neonate ducks with the image of their mother or the first being they encounter upon emerging from the egg shell [27, 28].

More recently, imprinting has been defined has a learning process occurring in a sensitive period under hormonal control. This process represents the main mechanism underlying selective parental care in ungulates [29].

For parents, offspring recognition limits energy expenditures and ensures reproductive success. Social, sexual, feeding and maternal behaviors are four basic aspects directly related to olfaction, which allow the animal to interact with the group (social behaviour), express feeding preferences (feeding behaviour) and find a mate (sexual behaviour) or take care of their offspring (maternal behaviour and mother–infant bonding), respectively [8, 30].

From the perspective of the offspring, recognizing their parents is essential for their welfare and survival, since the dams of most gregarious species feed only their own young [9]. Also, during the first months of life, the dams of all mammal species constitute the most important social contact for their offspring, a situation that facilitates feeding and care, as well as the acquisition of information on the physical and social environments [31]. Given these conditions, and with the goal of ensuring the survival of neonates, it is essential that the dam-calf bond develops from the moment of birth and through the immediate postpartum period [8].

As the calf passes through the birth canal during parturition it generates cervical-vaginal stimulation that activates the hypothalamus and releases oxytocin, a hormone that acts upon the cow's olfactory bulb. This, in turn, enables the secretion of dopamine, which initiates the sensitive period during which the dam identifies her own calf [4, 32]. In dairy cows, the first five minutes of contact with the calf immediately after birth are sufficient to form a strong dam-young bond specifically with her neonate [33-35]. Observations of this event in the Murrah and Surti breeds of water buffaloes have documented the development of epimeletic behavior (*i.e.*, the care and attention that the dam provides to her calf). After giving birth, the dam stands up [36] and begins to lick and smell her neonate [37]. In buffalo [36], dairy and beef cattle dams [38] this activity stimulates various activities in the calf, including the respiratory center, breathing, circulation, urination and defecation [36] (Figure **1**).

Beef cattle cows often ingest some, or all, of the placenta in the 2-6 h after parturition as they lick their calves and the fetal membranes [4, 39]. The time devoted to this behavior is greater in buffalo cows than heifers [37], but is similar to what has been observed in other ruminants (e.g. beef and dairy cattle and sheep).

The behavioral patterns of the neonate begin when it raises its head and adopts a ventral-sternal posture, followed by hesitant, sequential attempts to stand on all fours, first extending the thoracic extremities, then the pelvic ones. These movements allow the calf to reach the mammary gland and begin feeding [36]. Other behaviors include emitting vocalizations whose purpose is to call the dam's attention as part of the calf's survival strategy (et-epimeletic behavior) [36, 37]. In the context of these extra-uterine behavioral changes, the sex of the neonate seems to play a role, as female calves show faster development than male calves [37].

Figure 1: Sensory factors involved in mother-young bonding. Buffalo calf welfare. Chemical communication is particularly important in the management of mother-young relationships, and in various domestic mammals, parturient mothers clearly respond to the odours of their young [8, 10, 12, 40]. Precocial species (most ungulates) are characterized by a small litter of fully-developed young that are able to follow the mother shortly after birth (just 30 min), and that begin to suckle within 1 h. These young are also capable of perceiving olfactory, acoustic, visual and tactile cues from the environment [8, 10, 12, 41]. Source: Fabio Napolitano and Jesús Berdugo.

Studies in extensive production systems have documented that buffalo cows keep their newborn offspring hidden for several days postpartum, returning to them at night for feeding. This ensures the survival of the neonate [42]. This behavior of concealing calves also occurs in cattle and has been recently confirmed in Curraleiro Pé Duro beef calves, a bovine breed naturalized in Brazil. This survival strategy is manifested as well by some wild ungulates to protect their young from predators; however –according to the perceptions of producers– this behavior occurs more frequently in this breed than others, such as the Tabapuã, Nelore and Caracu breeds, also raised in Brazil. Other observations show that Curraleira cows may stray as far as 15-20 km from their calves as they search for water and food [38].

With respect to postpartum neonatal behavior, this seems to depend on the nature of maternal conduct. Studies of Surti buffaloes have shown that calves born to dams classified as 'very aggressive' and alert in terms of protection take less time to reach the udder, while their mothers devote more time to feeding them, compared to calves from dams categorized as 'indifferent or apathetic' [36]. In contrast, observations on *Bos taurus ibericus* and *Bos taurus aquitanicus* cattle raised in extensive systems –like the Curraleiro Pé Duro breed– show that heifers often abandon their offspring to look for water and food [38].

SUCKLING

The most important aspect of the birth process is that calves must quickly locate the udder and begin to suck their mothers' milk. This is because suckling and the maternal care that calves receive allow them to obtain nutrients and antibodies (IgG 24 hours post-birth) [18] and improve their welfare by ingesting the warm fluid that enables it to maintain its body temperature, while reducing mortality due to hypothermia and increasing their viability for productive development [18, 19].

In artificially reared dairy calves, handling practices like the physical separation of mother and young, interruption of suckling and changes in the living environment, stress the animals, induce abnormal behaviours and deprives calves from learning species-specific behaviors [39]. Some of the most common abnormal behaviours include: cross-sucking, licking or tongue-playing [34, 35, 43]. In the specific case of sheep, another precocial species where bonding is important for survival and behavioral development, artificially reared lambs (i.e. in absence of their mothers) develop an attachment to humans providing positive social interactions including feeding. The attachment is facilitated if these interactions are provided soon after birth [44].

On the other hand, Dubey *et al.* [36] observed that buffalo calves born to dams that show high maternal behavior were allowed more time to locate the udder and reach the teat, as well as between reaching the teat and sucking. In addition, they had a greater number of attempts to begin feeding compared to calves born to dams that manifest less maternal behavior, since the former help their calves reach the udder more quickly [36] (Figure **2**).

When neonates ingest the first liquid –called colostrum– they immediately begin to receive cellular immunity in a process that continues up to the fifth day. The cellular immunity provided by Murrah buffalo cow milk has been analyzed and found to contain macrophages as the most abundant cells in the colostrum directly after parturition, followed by lymphocytes and neutrophils, though at the moment of birth phagocytic activity is low in this milk (24%) and diminishes at day 5 postpartum (14%). Studies have further determined that the phagocytic index is highest in the first colostrum, but shows a downwards tendency in the ensuing days. With regard to nutrients, buffalo colostrum contains higher concentrations of fats and protein but lower lactose values. It is important to mention that protein levels decrease significantly up to day 5 [46].

Figure 2: Natural suckling in buffalo. The motivation to suckle at this age is very high, and the frequency of milk intake ranges between eight and 12 times a day [6, 29, 45]. Source: Jesús Berdugo.

Observations of the Curraleiro Pé Duro breed of *Bos taurus* show that calves are persistent in their

attempts to feed, especially when the dam is reluctant to let them suckle [38]. However, not all suckling behavior is related to the production of mother's milk, a research has demonstrated that 30.3-50.0% of the total duration of lactation by beef cattle involves suction without nutrition [19].

In *Bos taurus*, suckling behavior –including time spent at the teat and the frequency with which suction occurs– are breed-dependent. In the case of Curraleiro Pé Duro calves, each suckling session lasts approximately five minutes [38]. Paranhos Da Costa *et al*. [19], found that *Bos indicus* also presents differences in sucking behavior in accordance not only with breed but also in association with the prevailing environmental conditions. For the Gir, Nelore and Caracu breeds, those researchers determined that suction events increase at three moments of the day: early in the morning (from 6:00 to 7:00 h), just before midday (10:00-12:00 h), and in the afternoon (17:00-18:00 h). They obtained the following averages for these three breeds of calves: number of suctions for feeding purposes, 2.57±0.05 per 12 h; duration of feeding, 9.25±0.11 min per session; and total duration of feeding time, 23.76±0.47 min during the 12 h of observation. Likewise, they ascertained that sucking behavior was influenced by the age of the calves; that is, the total duration of each feeding session increased at the beginning due to the increase in the number of suction events that the calf performed to feed. However, when the calves reached 90 days of age, the number of suctions for feeding decreased [19]. In another study, Paranhos Da Costa *et al*. [47] observed that in Gir, Nelore, Caracu, and crossbred calves (*Bos indicus*) aged 30-60 days, the duration of suckling behavior increased only slightly and then remained constant up to 120 days of age. However, as the age of the calves advanced, the frequency of this behavior decreased. This same decrease in the incidence of feeding also appeared in older *Bos taurus* calves [38]. With respect to sex, Paranhos Da Costa *et al*. [47] found that male *Bos indicus* calves performed a higher number of sucking events for purposes of feeding, and that each event lasted longer than in the case of female calves.

Sucking can affect the emotional state of un-weaned calves. Emotion originates from the internal mental state of an individual in reaction to various stimuli, situation judgments, and expected responses [48]. An emotion is classically described through a behavioral component (a posture or an activity), an autonomic component (visceral and endocrine responses) and a subjective component (emotional experience or feeling) [49-51]. In this regard, Lv *et al*. [51] demonstrated that the negative emotions induced in female Holstein calves by the failure to feed at one month of age can affect their behavior, as shown by an increasing frequency of self-grooming behaviors, head-shaking, and tongue-rolling, accompanied by an increased heartbeat. In addition, those female calves had reduced immunity. In contrast, female calves that were successful in feeding and, therefore, experienced a positive emotional state, increased the expression of behaviors recognized as 'playful', together with higher levels of salivary secretory immunoglobulin A and serum interleukins 2 and 3, which are associated with immunocompetence [51]. Both calves experiencing positive and negative emotions displayed increased salivary cortisol levels. Lv *et al*. [51] suggest, that play behavior and salivary cortisol levels could be potential non-invasive measures for delineating positive emotional state of calves.

ALLOSUCKING

Allosucking (communal nursing) is an ordinary conduct in water buffalo (*Bubalus bubalis*), in *Bos taurus* calves [52] and in several other ungulate species such as *Cervus elaphus* [53] and *Ovis ammon* [54]. Cows promptly accepting their own offspring tended to accept non-filial calves as well [55]. In this activity, neonates suck milk from females that are not their biological mothers. Calves satisfy their nutritional needs and sucking behavior by feeding from the teats of their own mothers, but some may not obtain sufficient milk from their dams and so perform more frequent acts of allosucking [56]. Allosucking has been observed in the Curraleiro Pé breed, where sucking events include the dam, her own calf, and an orphan calf, usually of about the same age. Cattle cows, meanwhile, seem not to differentiate between the acts of grooming and suckling their own calves and calves from other dams [38].

The milk intake from a non-maternal female is believed to be beneficial for the allosucking infant as they ingest a milk surplus [57] with increased weight gains and potential immunological benefits deriving from sucking more than one nursing female [58]. However, allosucking may also be costly. In addition to the potential of risk of injury resulting from aggressive behaviour from the non-maternal female that is being solicited, pathogen transmission through the milk during allosucking may also reduce the benefits that young calves gain from this activity [56, 58].

This behavior has also been seen in calves with low birth weights, suggesting that allosucking might be a compensatory behavior in neonates with this condition, which tends to occur with primiparous dams, or when the offspring suffer from some type of nutritional deficiency [56]. Víchová and Bartoš [56] observed that allosucking is more frequent in female calves than males and in cattle calves compared to crossbred dairy calves. It is important to note that as the age of the offspring increases, allosucking behavior shows a tendency to decrease [56]. Similarly, in the case of buffaloes (*Bubalus bubalis)*, observations have shown that calves have greater success when approaching their own mothers for milk than when they seek it from some other buffalo cow; however, they tend to feed more often from females of the group where their mothers belong [59]. While buffaloes show high inter-individual variations in the behavior of accepting or rejecting approaches to the udder by their own and alien calves, the fact that some buffalo cows do allow alien calves to feed has been considered either an altruistic behaviour [55], or interpreted as a means of eliminating milk that was not ingested by their own young [60]. Likewise, the female buffaloes that allow both types of feeding (*i.e.*, by their own or alien calves) have higher indices of both daily and total milk production [59, 60]. Paranhos Da Costa *et al*. [47] observed that during the first 4 months of life, male buffaloes presented higher mean daily weight gain (0.490±0.13 Kg/day) and devoted more time to both sucking at their own dams' udder (2.25 times) and in communal feeding with other cows (2.4 times), compared to female calves, which presented higher mean times for sucking at their own mother's udder during communal lactation (2 times) [47, 61].

The existence of individual differences in female tolerance for communal sucking, reinforces the persistence of sucking attempts among calves. The cows do not neglect their own offspring when permitting allosucking, offspring are a constant presence during collective sucking. Some females seem to be more tolerant to the allosucking than others, an individual characteristic which is maintained throughout the lactation period [62] (Figure **3**).

The calves that frequently sucked non-maternal dams were most likely attempting to compensate for some deficiency, such as low birth weight and/or insufficient supply of maternal milk. This behaviour does not appear to have any negative effect on the progeny of the allonursing dams, possibly because they devoted to alien calves only the milk not ingested by their own offspring. Consequently, the allosucking calf should benefit without decreasing the fitness of the calves of the dams being allosucked [56]. In intensive systems buffalo calves are not allowed to suck from their mothers or alien females and often show cross-sucking, which can be defined as an oral abnormal behaviour expressed by calves and directed towards various body regions (navel, ears, prepuce, teats) of co-specifics. Pisani *et al*. [23] observed a positive relationship between cross-sucking and mortality with increased mortality rates in farms affected by a higher prevalence of cross-sucking. This may be at least partly explained by the fact that calves, which are

Figure 3: Communal nursing in water buffalo cows. A group of buffalo calves are allowed to simultaneously suck a buffalo cow. Source: Jesús Berdugo.

unable to satisfy their nutritional and behavioural needs when the milk substitute is offered, can not engage in allosucking and try to compensate by devoting their attention to the pen-mates. However, this behaviour is non nutritive while also causing the ingestion of microbial pathogens.

CONCLUSIONS

As for other precocial species, also for buffaloes the early post-partum period is a critical stage due to the fact that a mutual recognition and selective relationships develops in order to increase the fitness of the mother and the survival of the newborn buffalo calf. However, buffalo cows seem to be more tolerant than other ruminants towards alien calves and communal nursing is not uncommon in systems where calves and cows are allowed to stay in the same herd. In intensive systems, though, buffalo calves are prematurely separated from their mothers and receive reconstituted milk. Therefore, they experience a negative emotional state and often direct their frustrated sucking motivation towards the pen-mates with detrimental effects on the performers (ingestion of microbial pathogens) and the receivers (inflammation of various sucked organs such as navel, prepuce, etc.) with increased mortality rates. This review concludes that, based on the existing literature, buffalo, dairy and beef cattle calves show similar behaviors from parturition to weaning. However, additional studies are required to increase the knowledge about the specific needs of buffalo calves and implement appropriate management practices to increase their welfare and reduce mortality rates.

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