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RESEARCH ARTICLE

# Periparturient behavioural indicators for predicting calving in Murrah buffaloes under different bedding systems

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**Abstract:** Thirty multiparous pregnant Murrah buffaloes maintained at ICAR–National Dairy Research Institute (NDRI), Karnal, were individually housed in calving pens provided with straw bedding, rubber mats, or concrete flooring. Behavioural parameters, including lying time, lying bouts and tail-raising frequency were continuously monitored using CCTV cameras from five days before to five days after calving. Data were analyzed using a two-way ANOVA to assess the effects of day, bedding system, and their interaction. Results revealed a significant ($P < 0.05$) decline in lying time as calving approached, with the most pronounced reduction observed on the day of calving across all bedding systems. Buffaloes housed on straw bedding consistently exhibited higher lying times, indicating superior comfort. In contrast, lying bout frequency increased markedly during the pre-partum period, peaking on the day of calving with increases of approximately 92.78%, 95.61% and 71.92% in straw, rubber mat and concrete bedding systems, respectively. Tail-raising frequency showed the most distinct behavioural change, increasing sharply on the day of calving by 92.9–114.4% compared to pre-partum levels, irrespective of bedding type. The findings demonstrate that lying time, lying bouts, and tail-raising frequency are reliable behavioural indicators of impending calving in Murrah buffaloes. Among the bedding systems evaluated, straw bedding provided greater comfort during the peri-parturient period. These results highlight the potential application of behavioural monitoring for precision calving management to improve animal welfare and reproductive outcomes in intensive buffalo production systems.

**Keywords:** Bedding, Behaviour, Calving, Murrah

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## Introduction

India possesses a total livestock population of 536.76 million, of which buffaloes account for 109.85 million. Buffalo husbandry is a cornerstone of rural livelihoods and food security and plays a vital role in the economic sustainability of crop–livestock farming systems across Asian countries. Asia alone houses more than 97% of the world's buffalo population, with India leading globally by contributing approximately 57% of total buffalo numbers. India is also the world's largest milk producer, with production rising dramatically from 17 million tonnes (MT) in 1951 to an estimated 247.87 MT in 2025. Buffaloes contribute about 31.18% of India's total milk output, amounting to nearly 77.28 MT annually (BAHS, 2025). Calving represents one of the most critical physiological events in dairy animals, during which they must cope with extensive physical, physiological, environmental, and management-related stressors. Close monitoring of animals during late gestation is therefore essential to minimize calving-related complications (Jensen, 2012).

In buffaloes, maternal dystocia is reported to be more prevalent (59.82%) than fetal dystocia (40.17%), with uterine torsion identified as the predominant cause, accounting for 53.57% of dystocia cases (Purohit et al. 2012). The overall incidence of uterine torsion ranges from 1–2% (Kaushik and Mathur, 2005), with higher breed-specific prevalence reported as 5.6–12.6% in Murrah, 8.94% in Jaffarabadi, and 4.6–5.4% in Surti buffaloes (Khan et al. 2009). Although calving-related behavioral patterns in buffaloes resemble those of dairy cattle, notable quantitative differences—particularly in the duration of the first and second stages of parturition—are critical for predicting species- or breed-specific calving times (Mota-Rojas et al. 2020). Consequently, identifying gross behavioral changes associated with parturition is highly beneficial for dairy management, particularly for ensuring

the welfare of both dam and calf during pre-, peri-, and post-parturient periods (Dizier and Maillard, 2015).

Studies on primiparous Italian Mediterranean buffaloes revealed that increased lying, walking, and tail-raising behaviors are reliable indicators of imminent calving (Lanzoni et al. 2022). Furthermore, maternal rejection behavior in the postpartum period has been shown to negatively affect calf growth (Lanzoni et al. 2021), while early mother–calf bonding is critical for neonatal survival (Mota-Rojas et al. 2022). Continuous visual observation of animals over extended periods is labor-intensive, time-consuming, and impractical, particularly in large dairy herds. Precision dairy monitoring technologies employing non-invasive and non-contact methods address these limitations and reduce reliance on subjective assessment of calving indicators such as pelvic ligament relaxation, udder distension with teat swelling, vulvar edema, and hormonal fluctuations (Jensen et al. 2012). Behavioral monitoring studies in dairy cows using video surveillance systems have demonstrated that increased lying bouts can predict calving within approximately six hours (Fadul et al. 2017). Similarly, a marked rise in tail-raising activity about six hours prior to calving highlights its potential as a predictive behavioral indicator (Giaretta et al. 2021). A review of existing literature indicates a lack of comprehensive information on key behavioral parameters such as lying time, lying bouts, and tail-raising activity associated with the calving process in buffaloes. Detecting quantifiable behavioral changes like lying time, lying bouts, and tail-raising activity in individual animals is therefore essential for accurate prediction of parturition.

## Materials and Methods

The experiment was carried out on Murrah buffaloes at the ICAR–National Dairy Research Institute (NDRI), Karnal, Haryana, India. The animals were housed at the Livestock Research Centre (LRC), ICAR-NDRI, situated at an altitude of approximately 250 m above mean sea level (29.42°N latitude and 79.54°E longitude) and characterized by a subtropical climate. A total of 30 multiparous pregnant Murrah buffaloes maintained under a loose housing system were selected for the study. The study was conducted during the calving season from November 2024 to March 2025. The animals were transferred to individual calving pens 14 days prior to the expected date of calving and remained there until five days postpartum for colostrum feeding. One pen was provided with straw bedding covering both the indoor and outdoor areas, with fresh straw added daily and complete bedding replacement performed after each calving. The second pen was fitted with rubber mats covering most of the floor area, while the third pen served as the control with a concrete floor. Each pen accommodated ten Murrah buffaloes. Behavioural observations were recorded using night-vision 2-MP dome CCTV cameras (metal body, Android-compatible) installed inside and outside each calving pen to ensure full visibility of the animals. Continuous video recording was carried out from five days before the expected calving date (“5 d) to five days after calving (+5 d), allowing 24-hour monitoring of behavioural activities. The mean daily lying time, number of lying bouts (a period following standing during which the animal spent at least 50% of the time lying for a minimum of two consecutive minutes), and tail-raising activities (number of instances in which the tail was lifted from its base and held away from the body) were calculated for each animal (Munksgaard et al. 2001). The behavioural activities along with their descriptions are presented in Table 1.

### Statistical analysis

The data collected during the peri-parturient period (from day “5 to day +5 relative to calving) were statistically analyzed to facilitate meaningful interpretation of the results using IBM SPSS Statistics 20 software. Differences among treatment means were evaluated using the least significant difference (LSD) test, and significance was considered at $p < 0.05$.

## Results and Discussion

### Analysis of lying time during peri-partum period

The lying time of Murrah buffaloes housed on three different bedding systems—straw, rubber mat, and concrete—was evaluated from five days before to five days after calving. During the prepartum period (day “5 to day “1), buffaloes provided with straw bedding exhibited significantly higher ($p < 0.05$) lying times compared to those housed on rubber mats and concrete floors. For example, on day “5, lying time was highest in the straw-bedded group (692.2 ± 5.01 min), followed by the rubber mat (683.2 ± 0.57 min) and concrete floor (662.5 ± 0.72 min). A pronounced reduction in lying time was observed on the day of calving (day 0) across all bedding treatments. On this day, lying time declined to 551.7 ± 5.67 min for straw bedding, 538.5 ± 1.01 min for rubber mats, and 509.7 ± 0.75 min for concrete floors (Figure 1). However, buffaloes on straw bedding continued to exhibit comparatively higher lying times than those in the other two groups.

In the postpartum period (day +1 to day +5), lying time increased progressively in all bedding systems. On day +1, lying times

Table 1: Behavioural activities along with their description

| Behavioural activity | Description |
|---|---|
| Lying time (min/d) | Lying on sternum or side. Head may be rested or raised |
| Lying bouts (number/ d) | The number of times a buffalo gets up and down |
| Tail raising (number/ d) | Number of times tail raised from the base and held away from the body |

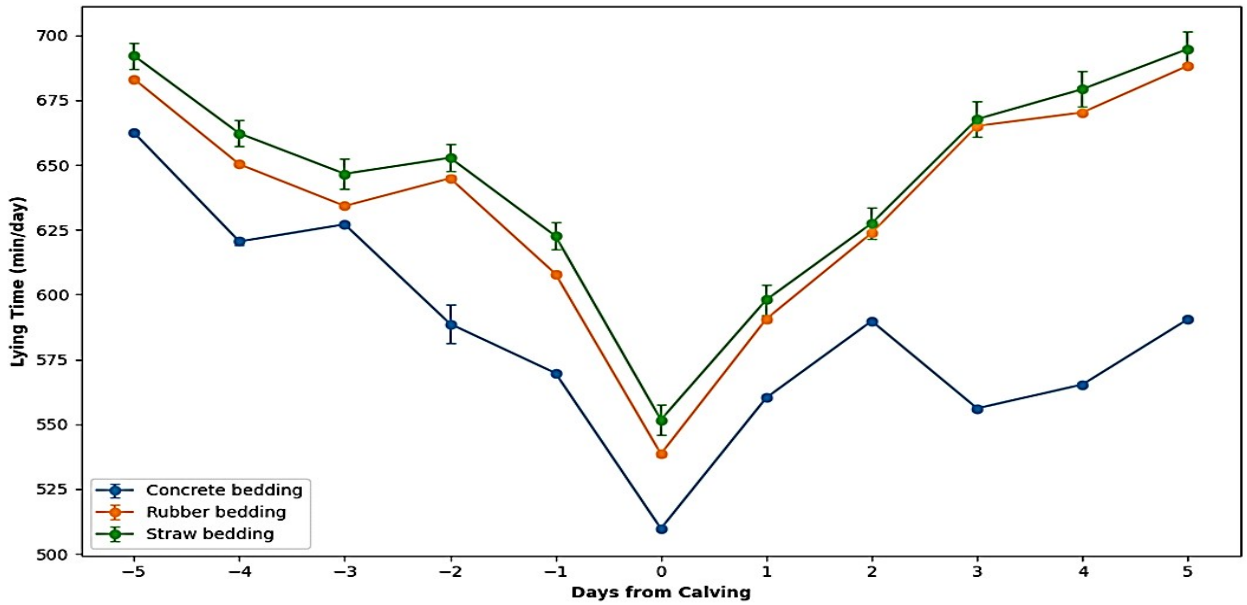



Fig.1 Lying time (min/day) in Murrah buffaloes (n=30) during the peri-partum period (5 days pre- and post-calving)

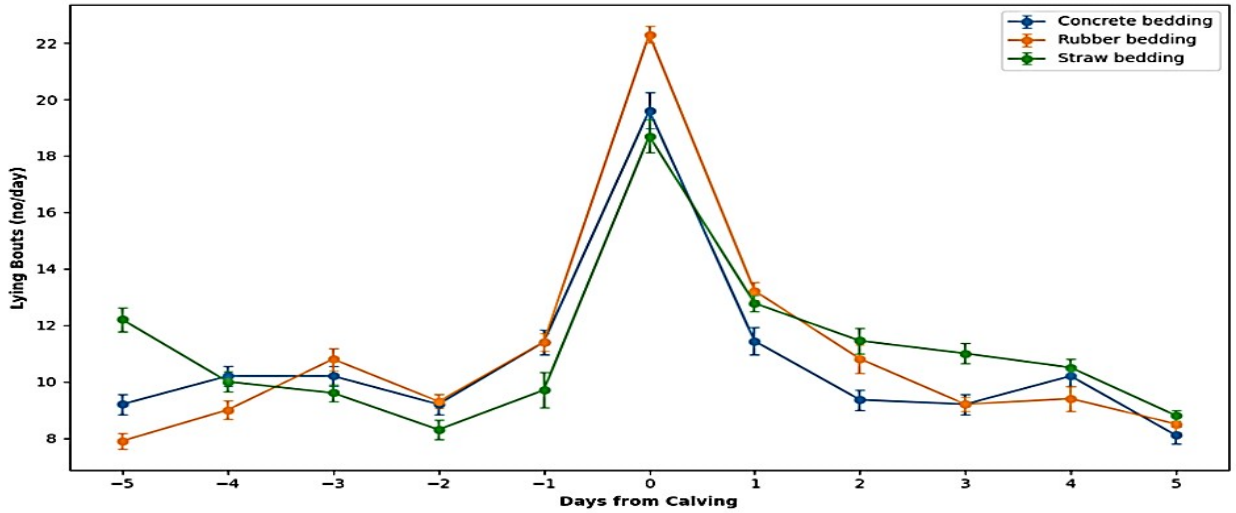



Fig. 2 Lying bout (number/day) in Murrah buffaloes (n=30) during the peri-partum period (5 days pre- and post-calving)

were recorded as 598.0 ± 5.84 min for straw, 590.6 ± 1.21 min for rubber, and 560.2 ± 0.76 min for concrete. By day +2, further increases were observed (627.5 ± 5.98, 623.8 ± 1.02, and 589.8 ± 0.44 min, respectively). This upward trend continued through day +3 (667.7 ± 6.77, 665.1 ± 0.90, and 556.1 ± 0.97 min), day +4 (679.3 ± 6.76, 670.3 ± 0.47, and 565.3 ± 0.68 min), and day +5 (694.8 ± 6.77, 688.3 ± 0.70, and 590.5 ± 0.75 min). Overall, straw bedding was most effective in maintaining higher lying durations, indicating improved welfare and resting behavior in periparturient Murrah buffaloes.

In comparision with Chopra (2026), who reported reduced lying time in Murrah buffaloes maintained on straw and rubber mat flooring systems before calving, the present study offers more comprehensive quantitative evidence supporting these behavioural changes. Furthermore, the decline in lying time observed in this study is consistent with previous findings in dairy cattle, where reduced lying duration prior to parturition had been documented under both indoor housing systems (Titler et al. 2015; Black and Krawczel, 2016)) and pasture-based management systems (Rice et al. 2017; Sepúlveda-Varas et al. 2018; Hendriks et al. 2019).

Table 2: Tail raising frequency (number/day) in Murrah buffaloes (n=30) during the peri-partum period (5 days pre- and post-calving)

| Bedding / Days from calving | $T_0$- Concrete | $T_1$-Rubber | $T_2$-Straw |
|---|---|---|---|
| -5 | $6.00^{Aa}$±0.26 | $6.90^{Aa}$±0.48 | $7.80^{Aa}$±0.33 |
| -4 | $7.00^{Aa}$ ±0.26 | $7.90^{Aa}$±0.28 | $7.70^{Aa}$±0.31 |
| -3 | $8.00^{Aa}$±0.26 | $9.90^{Aa}$±0.28 | $7.90^{Aa}$±0.31 |
| -2 | $8.10^{Aa}$±0.31 | $10.40^{Aa}$±0.27 | $9.50^{Aa}$±0.22 |
| -1 | $10.30^{Ab}$±0.37 | $12.70^{Ab}$±0.42 | $11.80^{Aab}$±0.25 |
| 0 | $20.60^{Ab}$±0.64 | $24.50^{Ac}$±0.37 | $25.30^{Ac}$±0.42 |
| +1 | $9.11^{Ab}$±0.35 | $10.67^{Ab}$±0.29 | $10.11^{Ab}$±0.38 |
| +2 | $9.00^{Ab}$±0.23 | $8.91^{Ab}$±0.39 | $8.18^{Aab}$±0.26 |
| +3 | $8.00^{Aa}$±0.26 | $8.40^{Aa}$±0.31 | $8.00^{Aa}$±0.33 |
| +4 | $7.00^{Aa}$±0.26 | $8.40^{Aa}$±0.27 | $8.00^{Aa}$±0.26 |
| +5 | $5.00^{Aa}$±0.26 | $6.90^{Aa}$±0.35 | $7.40^{Aab}$±0.27 |

Means with different lowercase superscripts (a–c) differ among days; different uppercase superscripts (A–C) differ between bedding types on the same day (p/ </ 0.05)

**Analysis of lying bout frequency during peri-partum period**

An evaluation of lying bouts in Murrah buffaloes from five days before to five days after calving across three bedding systems—straw, rubber mat, and concrete—revealed distinct behavioral patterns associated with the periparturient period.

Under the straw bedding system, the number of lying bouts ranged from 12.20 ± 0.42 on day "5 to 10.00 ± 0.36 on day "4. A significant rise was observed on day "1, with lying bouts increasing to 9.70 ± 0.63, followed by a marked peak on the day of calving (day 0) at 18.70 ± 0.58 bouts. After calving, lying bouts declined sharply to 12.78 ± 0.28 on day +1. On the day of calving, lying bouts increased by 87.75% relative to the mean prepartum value (Figure 2). In buffaloes housed on rubber mat bedding, lying bouts followed a comparable trend. Values decreased slightly from 7.90 ± 0.28 on day "5 to 9.00 ± 0.33 on day "4 and 10.80 ± 0.39 on day "3. A gradual increase was noted from day "2 (9.30 ± 0.26) to day "1 (11.40 ± 0.31), culminating in a pronounced peak on day 0 with 22.30 ± 0.30 bouts. Postpartum, lying bouts declined significantly to 13.22 ± 0.32 on day +1. The mean prepartum lying bout frequency (excluding day 0) was approximately 9.68, with a 130.37% increase observed on the day of calving compared to the prepartum average (Figure 2). For buffaloes maintained concrete flooring, lying bouts ranged from 9.20 ± 0.36 on day "5, increased to 10.20 ± 0.36 on day "4 and 10.20 ± 0.36 on day "3, and further rose on day "2 (9.20 ± 0.36) and day "1 (11.40 ± 0.43). The highest frequency was recorded on the day of calving, with 19.60 ± 0.64 bouts. Following calving, lying bouts decreased markedly to 11.44 ± 0.48 on day +1 and subsequently stabilized between 9.36 ± 0.36 on day +2 and 8.10 ± 0.31 on day +5. The average number of lying bouts during the prepartum period (excluding day 0) was approximately 10.04, and the day-of-calving value represented a 95.21% increase over the prepartum mean (Figure 2). The increase in lying bouts on the day of calving was most pronounced in buffaloes housed on rubber mats (22.30 ± 0.30 bouts; 95.61% increase), followed by concrete (19.60 ± 0.64 bouts; 71.92% increase) and straw bedding (18.70 ± 0.58 bouts; 92.78% increase).

Overall, the findings clearly indicate that the frequency of lying bouts increased progressively as calving approached, reached a distinct peak on the day of calving, and subsequently declined gradually during the postpartum period. The agreement of these observations with previous reports by Chopra (2026), Lanzoni et al. (2022), Ouellet et al. (2016) Miedema et al. (2011), Jensen (2012), and Hendriks et al. (2019) further supports the reliability of lying bout frequency as an important behavioural indicator of imminent calving.

**Analysis of tail-raising frequency during peri-partum period**

The frequency of tail-raising behaviour in buffaloes was evaluated from five days before to five days after calving under three different bedding systems—straw, rubber mat, and concrete. Across the observation period, tail-raising frequency remained relatively stable with minor day-to-day variations among bedding treatments. However, a marked and significant increase in tail-raising activity was recorded on the day of calving (day 0) across all bedding systems. Buffaloes housed on straw bedding exhibited a sharp rise in tail-raising frequency on the day of calving, reaching 25.30 ± 0.42 events. Similarly, animals maintained on rubber mats recorded the highest frequency at 24.50 ± 0.37, while those on concrete flooring showed a frequency of 20.60 ± 0.64. In contrast, the mean tail-raising frequency during the prepartum period (day "5 to day "1) ranged from 7.80 to 11.80 for straw bedding, 6.90 to 12.70 for rubber mat bedding, and 6.00 to 10.30 for concrete flooring (Table 2). When compared with the average pre-partum values, tail-raising frequency on the day of calving increased by approximately 114.40% in the straw-bedded group, 92.91% in the rubber mat group and 100% in the concrete group. This pronounced elevation in tail-raising activity on the day of parturition reflects a key behavioural shift associated with the

calving process, likely indicating increased restlessness, discomfort, or physiological changes occurring during this critical period.

This observation aligns with the findings of Lanzoni et al. (2022) and Ouellet et al. (2016), who reported that although environmental conditions may influence animal comfort, they do not substantially alter the core behavioural indicators associated with calving. This behaviour has already been incorporated into automated calving detection systems employing technologies such as inclinometers and accelerometers (Mee et al. 2019). Nevertheless, Saint-Dizier and Chastant-Maillard (2015) emphasized the need for further validation before widespread field-level implementation. The present study further highlights the potential of integrating automated monitoring of tail-raising behaviour in buffaloes for real-time calving prediction. Such technologies could contribute to improved calving management, reduced incidence of complications such as dystocia, and enhanced calf survival as well as maternal welfare.

**Conclusion**

Timely and accurate prediction of calving is critical for enhancing reproductive efficiency and minimizing health risks to both dams and calves. From the results, it inferred that lying time declined significantly on the day of calving, while lying bouts and tail-raising frequency increased markedly as parturition approached. The study demonstrates that behavioral parameters such as lying time, lying bouts, and tail-raising frequency provide reliable, objective markers for predicting calving in Murrah buffaloes.

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