Feeding and rumination behaviour as non-invasive indicators of impending calving in periparturient Murrah buffaloes housed on straw bedding

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Abstract

Eighteen clinically healthy multiparous Murrah buffaloes (parity 2–4) housed in individual straw-bedded maternity pens were observed by continuous CCTV from seven days before to five days after calving. Feeding and rumination durations were evaluated daily (D−7 to D+5), as mean minutes per hour within consecutive six-hour prepartum blocks (−120 to −6 h), and hourly during the last 24 h. Repeated-measures analysis of variance assessed temporal variation within animals; Greenhouse–Geisser-adjusted tests were used for daily observations. Feeding declined from 325.89 min/day at D−7 to 207.78 min/day at D0, a 36.03% decrease relative to the D−7 to D−1 mean. Rumination declined from 448.44 to 313.83 min/day (29.22% below the prepartum mean). Six-hour-block feeding averages declined by 67.27% from −120 to −6 h and rumination by 46.81% from −24 to −6 h. Hourly feeding and rumination decreased by 84.09% and 87.08%, respectively, from −24 to −1 h. Time effects were significant at all resolutions (all $P < 0.001$). Both behaviours increased after calving, approaching earlier prepartum values by D+4 to D+5. Feeding and rumination may be promising non-invasive indicators of approaching parturition, but prospective predictive performance was not assessed.

Keywords: Murrah buffalo, feeding time, rumination, periparturient behaviour, calving monitoring.

Introduction

The livestock sector is central to India's socioeconomic development, providing food, draught power, employment, and financial security (Meo Zilio et al., 2020; Quddus et al., 2022). Buffaloes contribute over half of the nation's milk due to their adaptability, disease tolerance, and high milk solids, despite being fewer than cattle (Ermetin, 2021; Sharma et al., 2025). Maintaining their productivity requires effective management of feeding, housing, health care, and reproduction throughout the calving cycle (Quddus et al., 2022; Stevenson, 2022). Calving is a critical physiological event, involving three stages that culminate in fetal and placental expulsion (Noakes, 2001; Wehrend et al., 2006; Miedema et al., 2011a; Schuenemann et al., 2011). Accurate prediction and close monitoring are essential to prevent losses from dystocia, stillbirths, and postpartum complications and to enable timely intervention (González-Lozano et al., 2020; Napolitano et al., 2013; Purohit et al., 2011, 2012; Mota-Rojas et al., 2019). Traditionally, calving prediction has relied on breeding records and anatomical signs such as pelvic ligament relaxation, vulvar edema, and udder engorgement (Wehrend et al., 2006; Miedema et al., 2011a; Santos et al., 2022), supplemented by behavioural cues including reduced feed intake, restlessness, and increased posture changes (Jensen, 2012; Barraclough et al., 2020; Giaretta et al., 2021; Cavendish et al., 2021). However, these methods are labour-intensive and observer-dependent, limiting their use in larger herds (Ouellet et al., 2016; Quddus et al., 2022; Santos et al., 2022). To address this, precision livestock farming (PLF) tools now provide objective monitoring of behavioural and physiological indicators using automated sensors (Crociati et al., 2021; Van Erp-Van der Kooij, 2021). In dairy cows, devices such as ear tags, neck collars, ruminal boluses, intravaginal probes, and tail sensors are widely used to track activity, posture, temperature, and calving events (Pahl et al., 2014; Ouellet et al., 2016; Crociati et al., 2021). Although PLF adoption in buffaloes is still limited, recent work with intravaginal sensors and activity meters shows promising potential for calving detection (Rossi et al., 2020; Ermetin, 2021; Meo Zilio et al., 2020). Feeding and rumination are key behavioural indicators of physiological status during the periparturient period, with both behaviours declining markedly as calving approaches (Soriani et al., 2012; Schirmann et al., 2013; Calamari et al., 2014). Feeding time and DMI typically fall by 30–40% on the day of calving, with the steepest reductions occurring in the final 8–6 hours prepartum due to discomfort and hormonal changes (Huzzey et al., 2007; Proudfoot et al., 2009; Miedema et al., 2011a; Büchel & Sundrum, 2014). Rumination also decreases progressively during the last week of gestation and may cease 4–6 hours before calving, resuming several hours postpartum (Pahl et al., 2013; Pahl et al., 2014; Borchers et al., 2017). Automated sensors that monitor feeding and rumination have shown strong potential for calving prediction (Ouellet et al., 2016; Clark et al., 2015). In buffaloes, similar prepartum declines have been reported, with rumination reaching its nadir around 2 hours before calving (Quddus et al., 2022). However, behavioural expression varies with species, parity, and housing, emphasizing the need for buffalo-specific data (Lanzoni et al., 2022; Stevenson, 2022). Given the influence of bedding on comfort and behaviour, detailed assessments under straw housing remain limited. Therefore, this study evaluated day-wise, 6-hourly, and hourly feeding and rumination patterns in periparturient Murrah buffaloes to assess their usefulness as practical, non-invasive indicators of impending calving.

Materials and methods

Study site and duration

The study was conducted at the Livestock Research Centre of ICAR–National Dairy Research Institute (NDRI), Karnal, Haryana, India, over an 18-month period from July 2022 to December 2023. All procedures relating to housing, feeding, breeding and welfare followed the institutional guidelines. Each buffalo was individually identified with ear tags to enable precise behavioural tracking throughout the experiment.

Experimental animals and management conditions

A prospective observational design was adopted involving 18 clinically healthy, pregnant multiparous Murrah buffaloes (parity 2–4) approaching parturition. Approximately two weeks before their expected calving dates, the animals were moved to individual maternity pens fitted with straw bedding, ensuring a uniform housing condition for behavioural evaluation. The pens had gable-type asbestos roofing and three solid walls (4.5 ft height), and each was connected to an outdoor paddock to allow natural movement. Pens were cleaned daily to maintain consistent environmental hygiene. The feeding regimen consisted of ad libitum access to seasonal green fodder, wheat straw, and a concentrate mixture containing approximately 20% crude protein and 70% total digestible nutrients, offered at 1.5–2.0 kg per animal per day in divided meals. Fresh drinking water was available at all times. Management practices adhered to standard welfare protocols to minimise stress and avoid confounding influences.

Behavioural monitoring and data Capture

Behaviour was continuously recorded using two fixed night-vision CCTV cameras per maternity pen. Complete calf expulsion defined the time of calving. Feeding was scored as visible active ingestion or chewing of feed at the feeder, excluding mere muzzle presence without ingestion. Rumination was scored as visible repeated cud-chewing jaw movements, whether the animal was standing or lying. Durations were tabulated per

animal at daily, hourly and six-hour-block resolutions. Each six-hour value denotes the mean number of minutes per hour within that block (the block total divided by six), not total minutes in six hours.

Statistical analysis

Feeding and rumination were analysed separately for each temporal resolution using one-factor repeated-measures ANOVA, with time relative to calving as a within-animal factor and animal identity as the repeated unit (n = 18). Means and standard errors (SE) were calculated from individual-animal observations. The residual distribution was assessed by Q–Q plots and Shapiro–Wilk tests; Mauchly's test was available for the daily analyses, and Greenhouse–Geisser-corrected degrees of freedom and P-values are reported for those analyses. Holm-adjusted paired contrasts were used for comparisons among time points. Data-quality screening identified no missing observations. Six-hourly and hourly feeding residuals departed from normality (Shapiro–Wilk P = 0.0012 and P = 0.0003, respectively); results for these outcomes therefore warrant caution. All analyses were conducted in R version 4.3.1 using afex, emmeans, dplyr and ggplot2. Significance was assessed at $P < 0.05$. Temporal trajectories are presented as mean ± SE, with the six-hour-block outcome expressed in mean min/h within each six-hour period.

Series	F	df	Uncorrected P
FEED_DAY	34.71	12, 204	7.78e-43
RUMI_DAY	13.34	12, 204	4.09e-20
FEED_6HR	11.38	19, 323	3.37e-26
RUMI_6HR	9.40	19, 323	1.47e-21
FEED-HOURLY	3.85	23, 391	1.61e-08
RUMI-HOURLY	4.18	23, 391	1.37e-09

Results

Day-wise feeding and rumination behaviour during the peripartum period in Murrah buffaloes:

The day-wise assessment of feeding and rumination time from 7 days before calving to 5 days after calving in Murrah buffaloes maintained on straw bedding revealed marked alterations around parturition (Table 1; Fig. 1).

Feeding time (min/day)

Feeding time decreased from 325.89 ± 8.86 min/day at D−7 to 207.78 ± 7.41 min/day at D0. Relative to the D−7 to D−1 mean (324.80 min/day), this was a 36.03% reduction. The effect of day was significant (Greenhouse–Geisser-adjusted $F(5.83, 99.11) = 34.71$, $P < 0.001$). Feeding increased postpartum, reaching 348.00 ± 9.60 min/day by D+4 (Table 1; Fig. 1).

Rumination time (min/day)

Rumination decreased from 448.44 ± 15.00 min/day at D−7 to 313.83 ± 10.24 min/day at D0, representing a 29.22% decrease relative to the D−7 to D−1 mean (443.40 min/day), or 30.02% relative to D−7 alone. The day effect was significant (Greenhouse–Geisser-adjusted $F(6.12, 104.04) = 13.34$, $P < 0.001$). Rumination recovered to 465.00 ± 16.54 min/day by D+4 (Table 1; Fig. 1).

Feeding and rumination behaviour at 6-hour intervals from 120 h to 6 h before calving:

A finer temporal assessment at 6-hour intervals from 120 h to 6 h before calving revealed a gradual but consistent reduction in both feeding and rumination time as parturition approached (Table 2; Fig. 2).

Table 1. Day-wise feeding and rumination time (min/day) of Murrah buffaloes (n = 18) from 7 days before to 5 days after calving

Day from Calving	Feeding time (min/day)	Rumination time (min/day)
D −7	224.22 ± 6.40	375.11 ± 11.49
D −6	325.89 ± 9.11	448.44 ± 15.43
D −5	324.00 ± 8.76	466.50 ± 11.59
D −4	348.00 ± 9.87	465.00 ± 17.01
D −3	319.61 ± 5.82	439.67 ± 12.21
D −2	260.67 ± 5.50	416.61 ± 10.64
D −1	224.22 ± 6.40	375.11 ± 11.49
D 0	207.78 ± 7.62	313.83 ± 10.53
D +1	224.22 ± 6.40	375.11 ± 11.49
D +2	260.67 ± 5.50	416.61 ± 10.64
D +3	319.61 ± 5.82	439.67 ± 12.21
D +4	348.00 ± 9.87	465.00 ± 17.01
D +5	324.00 ± 8.76	466.50 ± 11.59

Values are presented as mean ± SE (n = 18).

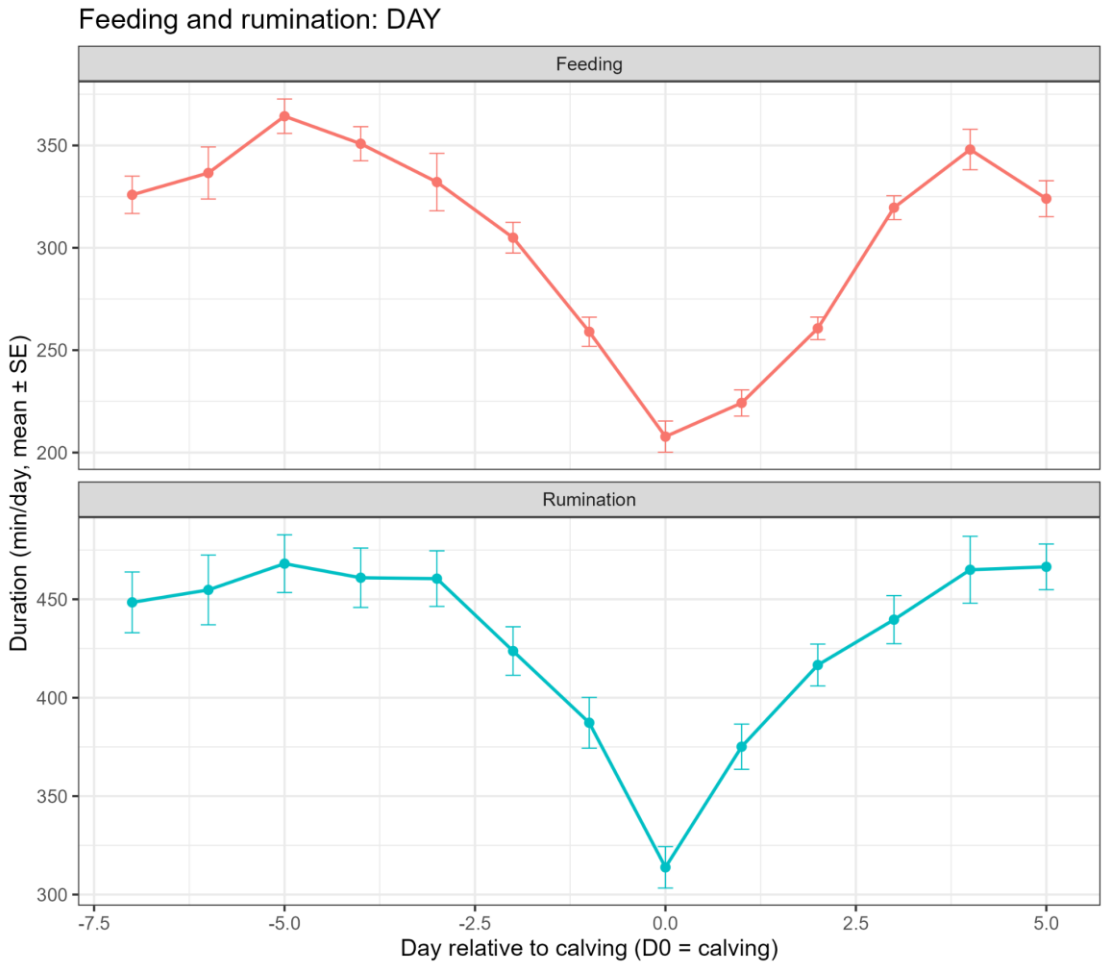


Figure 1. Daily feeding and rumination duration from D−7 to D+5 (mean ± SE; n = 18).

Feeding time (mean min/h within 6-h block)

Feeding time at 120 h prepartum was 15.93± 1.13 min, and values remained relatively stable between 14–16 min up to 96–90 h before calving (Table 2). Thereafter, a progressive decline was observed, with feeding time decreasing to 11.99 ± 0.82 min at 72 h, and further to 11.48 ± 0.55 min at 24 h. The most pronounced reduction occurred in the final 12 h, where feeding time dropped to 7.56 ± 0.61 min at 12 h and 5.21[a] ± 0.29 min at 6 h, indicating a 67.3% decline between 120 h and 6 h prepartum (Table 2; Fig. 2).

Rumination time (mean min/h within 6-h block)

Rumination time showed consistently high values around 18–20 mean min/h within 6-h block from 120 h to approximately 78 h before calving, with peaks at 20.53 ± 0.73 min (102 h) and 20.06 ± 1.12 min (78 h) (Table 2). A gradual decrease set in from 72 h prepartum (16.15 ± 0.73 min) and continued to 14.50 ± 0.57 min at 24 h and 14.26± 0.82 min at 18 h. The lowest rumination time was recorded at 6 h before calving (7.71 ± 0.52 min), which corresponded to a 46.8% reduction from 24 h to 6 h prepartum (Table 2; Fig. 2).

Overall, the 6-hourly data corroborate the day-wise pattern, confirming a significant depression in both feeding and rumination activities, especially during the last 24–6 h prior to calving in Murrah buffaloes housed on straw bedding.

Hourly feeding and rumination behaviour from 24 h to 1 h before calving:

Hourly observations from 24 h to 1 h before calving provided a high-resolution picture of the behavioural changes during the immediate prepartum period (Table 3; Fig. 3).

Feeding time (min/h)

Feeding time at 24 h prepartum was 12.22 ± 1.89 min, and remained between approximately 9–13 min up to around 15–14 h before calving (Table 3). Thereafter, a marked downward trend was evident, with feeding time decreasing to 7.00 ± 1.29 min at 11 h, 6.17 ± 0.91 min at 10 h, and remaining below 8 min from 11 h onward. The lowest value was recorded at 1 h before calving (1.94 ± 0.36 min), reflecting an 84.1% reduction relative to 24 h prepartum (Table 3; Fig. 3).

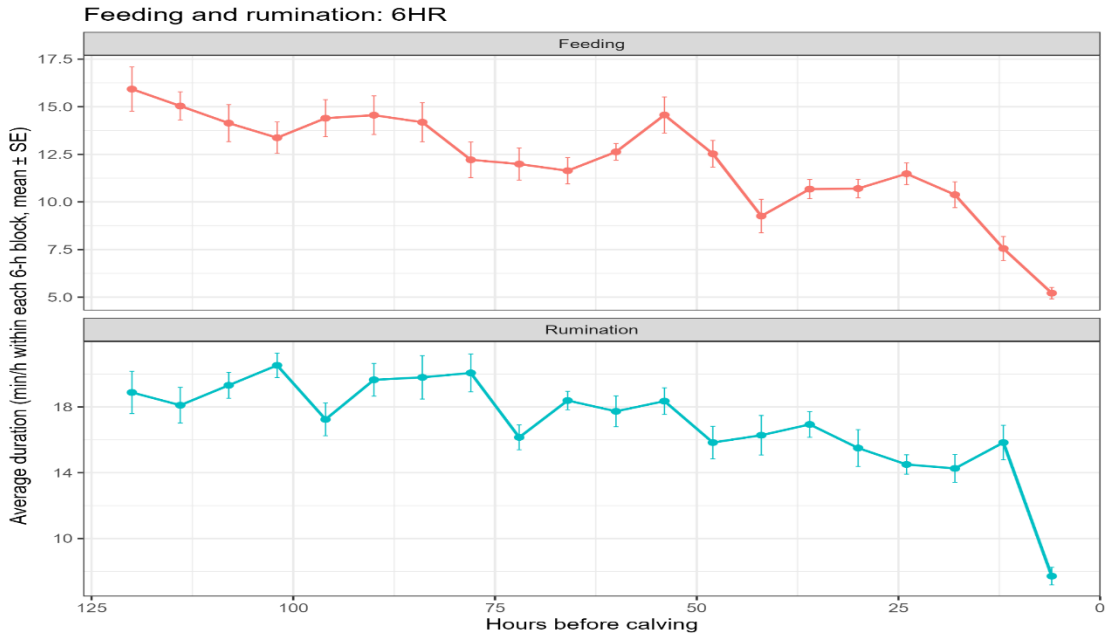


Figure 2. Feeding and rumination averaged within consecutive six-hour prepartum blocks (mean minutes per hour ± SE; n = 18).

Table 2. Feeding and rumination time (mean min/h within 6-h block) of Murrah buffaloes (n = 18) from 120 h to 6 h before calving

Hours before calving	Feeding time (min/6 h)	Rumination time (min/6 h)
120 h	15.93 ± 1.16	18.88 ± 1.29
114 h	15.04 ± 0.75	18.10 ± 1.09
108 h	14.14 ± 0.97	19.31 ± 0.79
102 h	13.37 ± 0.83	20.53 ± 0.75
96 h	14.40 ± 0.97	17.24 ± 1.00
90 h	14.56 ± 1.01	19.65 ± 1.00
84 h	14.19 ± 1.03	19.80 ± 1.32
78 h	12.21 ± 0.93	20.06 ± 1.15
72 h	11.99 ± 0.84	16.15 ± 0.75
66 h	11.64 ± 0.69	18.39 ± 0.56
60 h	12.63 ± 0.44	17.73 ± 0.94
54 h	14.56 ± 0.95	18.35 ± 0.81
48 h	12.53 ± 0.70	15.83 ± 0.99
42 h	9.26 ± 0.88	16.28 ± 1.20
36 h	10.68 ± 0.50	16.94 ± 0.78
30 h	10.70 ± 0.49	15.50 ± 1.12
24 h	11.48 ± 0.57	14.50 ± 0.59
18 h	10.38 ± 0.68	14.26 ± 0.84
12 h	7.56 ± 0.63	15.83 ± 1.05
6 h	5.21 ± 0.30	7.71 ± 0.53

Values are presented as mean ± SE (n = 18).

Rumination time (min/h)

Rumination time was relatively high at 18.06 ± 2.11 min at 24 h prepartum, with fluctuations between 12–18 min up to about 10–9 h before calving (Table 3). Notable peaks were seen at 13 h (17.06 ± 2.61 min) and 11 h (18.06 ± 2.20 min). Thereafter, a steep and continuous decline was observed, with rumination decreasing to 8.72 ± 1.26 min at 4 h, 7.39 ± 1.08 min at 3 h, 4.94 ± 1.06 min at 2 h, and ultimately 2.33 ± 0.50 min at 1 h before calving. This represented an 87.1% reduction from 24 h to 1 h prepartum (Table 3; Fig. 3).

The hourly profiles clearly demonstrate that both feeding and rumination activities are drastically suppressed in the last few hours prior to calving in buffaloes housed on straw bedding, supporting the use of these behavioural parameters as potential indicators of impending parturition.

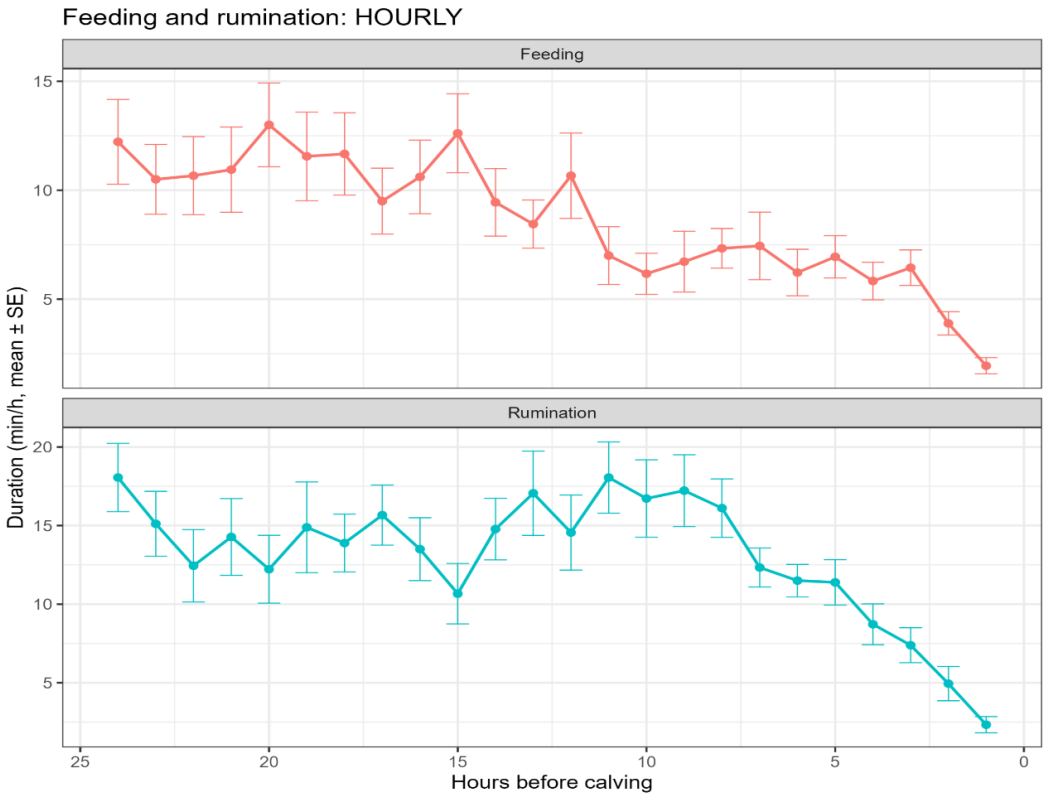


Figure 3. Hourly feeding and rumination duration during the final 24 h before calving (mean ± SE; n = 18).

Table 3. Feeding and rumination time (min/h) of Murrah buffaloes (n = 18) from 24 h to 1 h before calving

Hours before calving	Feeding time (min/h)	Rumination time (min/h)
24 h	12.22 ± 1.94	18.06 ± 2.17
23 h	10.50 ± 1.60	15.11 ± 2.07
22 h	10.67 ± 1.79	12.44 ± 2.30
21 h	10.94 ± 1.95	14.28 ± 2.44
20 h	13.00 ± 1.92	12.22 ± 2.16
19 h	11.56 ± 2.03	14.89 ± 2.89
18 h	11.67 ± 1.89	13.89 ± 1.84
17 h	9.50 ± 1.51	15.67 ± 1.91
16 h	10.61 ± 1.69	13.50 ± 2.00
15 h	12.61 ± 1.81	10.67 ± 1.92
14 h	9.44 ± 1.55	14.78 ± 1.96
13 h	8.44 ± 1.11	17.06 ± 2.68
12 h	10.67 ± 1.96	14.56 ± 2.39
11 h	7.00 ± 1.33	18.06 ± 2.26
10 h	6.17 ± 0.94	16.72 ± 2.46
9 h	6.72 ± 1.40	17.22 ± 2.28
8 h	7.33 ± 0.91	16.11 ± 1.86
7 h	7.44 ± 1.55	12.33 ± 1.24
6 h	6.22 ± 1.07	11.50 ± 1.03
5 h	6.94 ± 0.97	11.39 ± 1.44
4 h	5.83 ± 0.86	8.72 ± 1.30
3 h	6.44 ± 0.81	7.39 ± 1.11
2 h	3.89 ± 0.54	4.94 ± 1.09
1 h	1.94 ± 0.37	2.33 ± 0.52

Values are presented as mean ± SE (n = 18).

Discussion

Feeding and rumination decreased as calving approached and recovered during the first postpartum days. The observed decline in feeding is consistent with periparturient reductions in dairy cattle (Huzzey et al., 2007; Schirmann et al., 2013), whereas the rumination trajectory agrees with observations in transition cows (Soriani et al., 2012; Calamari et al., 2014). The daily reductions of 36.03% in feeding and 29.22% in rumination, relative to their respective prepartum means, indicate marked behavioural changes associated with parturition.

The six-hour series represent mean minutes per hour within each block rather than cumulative six-hour totals. This resolves the apparent difference in scale between the six-hour and daily tables. Feeding fell by 67.27% from −120 to −6 h, while rumination fell by 46.81% from −24 to −6 h. Previous studies likewise report decreased ingestive and rumination activity near calving (Büchel and Sundrum, 2014; Pahl et al., 2014).

Hourly records revealed a more pronounced decline close to parturition, with feeding and rumination decreasing by 84.09% and 87.08%, respectively, between −24 and −1 h. Such changes may be useful for identifying animals requiring closer supervision, but the present study did not test alarm thresholds, sensitivity, specificity or prospective prediction accuracy (Clark et al., 2015; Ouellet et al., 2016).

The animals were all multiparous (parity 2–4), and parity-specific effects were not estimated. Since only straw-bedded pens were observed, the study cannot establish an effect of bedding material on behaviour. The non-normal residual distributions for six-hourly and hourly feeding also suggest caution when interpreting parametric contrasts.

Limitations include the relatively small sample (n = 18), restriction to parity 2–4, a single housing substrate and the absence of independent prospective validation. Inter-observer reliability was not quantified. Larger multi-herd studies with validated scoring and prospective alert evaluation are required to establish generalisability and predictive utility.

In conclusion, feeding and rumination decreased before and on the day of calving and recovered by approximately four to five days postpartum in multiparous Murrah buffaloes housed on straw bedding. These behavioural measures are promising non-invasive indicators of approaching parturition; their predictive accuracy requires prospective validation.

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Author contributions

Deepak Chopra conceived and designed the study under the guidance of Dr. Arun Kumar Misra, Tushar Kumar Mohanty, Rubina Baithalu and Indu lathwal. Deepak Chopra conducted the research experiment and did the data analysis. Dr. Chinmayee Sahu, Dr. Simran Kamboj, Dr. Birender Singh, Pratibha Jareda interpreted the findings. Deepak Chopra wrote the manuscript. Dr. Arun Kumar Misra and Dr. T.K Mohanty proofread the manuscript after Rubina K Baithalu and Indu Lathwal finalized it. All authors reviewed the results and approved the final version of the manuscript.

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Data availability

The datasets generated during the current study are not publicly available; however, they are available from the corresponding author upon reasonable request.

Declarations

Ethical approval: The observational study was conducted at ICAR–National Dairy Research Institute, Karnal, under institutional animal-welfare guidelines and project proposal no. 51-IAEC-24-13.

Conflict of interest

The authors declare that they have no conflict of interest.

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