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EDITED BY
Charley-Lea Pollard,
Department of Agriculture, Fisheries and Forestry, Australia

REVIEWED BY
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Chulalongkorn University, Thailand
Naod Thomas Masebo,
University of Bologna, Italy

*CORRESPONDENCE
Nabil Mansour
nabil.mansour@fcpo.ae

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Automated activity analysis of pregnant, pre-partum, and post-partum dromedary female camels using YOLOv8 and SAMURAI tracking

Nabil Mansour[1,2*], Fawaghy Alhashmi[1,3], Hisham Cholakkal[3], Mostafa Nasef[4] and Fouad Lamghari[1]

[1]Department of Camel Research, Fujairah Research Centre (FRC), Fujairah, United Arab Emirates, [2]Department of Theriogenology, Faculty of Veterinary Medicine, Kafrelsheikh University, Kafr El-Sheikh, Egypt, [3]Deptartment of Computer Vision, Mohamed bin Zayed University of Artificial Intelligence (MBZUAI), Abu Dhabi, United Arab Emirates, [4]Bulaida Farms, Raibal Group, Fujairah, United Arab Emirates

Introduction: Behavioral monitoring during reproductive stages is vital for camel welfare and effective farm management. This study aimed to assess daily activity patterns in pregnant, prepartum, and postpartum dromedary camels using AI-based video analysis tools.
Methods: Two experiments were conducted under farm conditions in Fujairah, UAE. In Experiment 1, YOLOv8 with SAMURAI tracking analyzed short 15-minute video segments from 25 pregnant camels at selected times. In Experiment 2, 12 camels with colored neck collars were continuously monitored during late pregnancy, parturition, and postpartum.
Results: In Experiment 1, camels exhibited clear circadian rhythms, with increased sitting and sleeping activities at night, and heightened eating, drinking, and standing/walking during daylight hours. In Experiment 2, significant behavioral shifts were observed across reproductive states. Prepartum camels displayed elevated standing durations (699.7 $\pm$ 45.7 min/day) and reduced eating (128.3 $\pm$ 48.2 min/day), indicating prepartum restlessness. Postpartum camels gradually regained normal activity levels, with increased sitting (722.3 $\pm$ 65.4 min/day), sleeping (194.0 $\pm$ 15.4 min/day), and eating (229.1 $\pm$ 20.9 min/day) within the first 24 hours after calving.
Discussion: These findings validate the use of the YOLOv8–SAMURAI system and long-term collar-based identification as reliable, non-invasive tools for automated camel activity assessment. The observed activity markers provide meaningful indicators for reproductive status and recovery, enabling early detection of health or welfare issues. This research supports the development of precision management systems for camels in intensive farming environments.

KEYWORDS

dromedary camels, artificial intelligence, YOLOv8–SAMURAI tracking, reproductive management, welfare

Introduction

Dromedary camels (*Camelus dromedarius*) hold substantial cultural and economic significance in arid and semi-arid regions, especially in the Arabian Peninsula. Traditionally adapted to extensive systems, camels naturally engage in extensive daily activities such as grazing, browsing, and traveling considerable distances in search of food and water, displaying remarkable resilience to harsh desert conditions (Bouaouda et al., 2014; Farsi et al., 2020; Tibary and El Allali, 2020). However, the shift towards intensified management practices, characterized by restricted housing, limited mobility, and controlled feeding, has significantly impacted camel behavior, welfare, and stress responses (Aubè et al., 2017; Moideen et al., 2025). Such conditions have been associated with immune and hormonal disruptions, heightened occurrence of abnormal behaviors, and reproductive challenges, including prolonged calving intervals, increased dystocia, and elevated rates of calf rejection and mortality (Hammadi et al., 2021b; Tibary and Anouassi, 2001; Hussen and Al-Sukruwah, 2022).

Artificial intelligence and computer vision are transforming livestock monitoring by enabling continuous, non-invasive tracking of key behaviors such as feeding, resting, locomotion, and social interactions which are critical indicators of animal health, stress, and welfare (Nasirahmadi et al., 2017; Rohan et al., 2024). Traditional observation methods or wearable sensors are often labor-intensive, time-limited, and prone to observer bias, whereas AI systems offer scalable, efficient, and objective alternatives. Behavioral monitoring is essential for early detection of health issues, with abnormal activities often signaling discomfort, disease, or environmental stressors (Rice et al., 2017). Recent advances in AI and deep learning have further enhanced the accuracy and applicability of automated animal behavior analysis, particularly through video-based computer vision systems (Padalino and Menchetti, 2021). These technologies allow for high-resolution temporal and spatial analysis of animal activities without disrupting their natural environment. Object detection models such as YOLO (You Only Look Once), when integrated with advanced tracking algorithms like SAMURAI and DeepSORT, provide powerful tools for real-time monitoring of various animal species (Khiem et al., 2025; Yang et al., 2024a). Such innovations support proactive management strategies, improve animal welfare, and optimize productivity in modern farming systems.

In camels, computer vision-based behavioral monitoring systems have primarily focused on daily activities and maternal behaviors, critical for improving neonatal survival and optimizing management practices (Al-Khateeb et al., 2024; Hammadi et al., 2021a, b; Mansour et al., 2024). Our previous studies have established the reliability of deep learning methods, notably YOLOv7, in accurately classifying camel activities, including feeding, drinking, standing, sitting and sleeping in immature and pregnant camels shortly before parturition (Al-Khateeb et al., 2024; Mansour et al., 2024).

The current study conducted two experiments to analyze the daily activity patterns of pregnant, prepartum, and postpartum camels under controlled farm conditions. The first used the YOLOv8 model with SAMURAI tracking on short-term video clips (15-minute intervals), while the second involved continuous monitoring using color-coded neck collars for individual identification. This approach offers new insights into activity variations during pregnancy, pre-partum and postpartum periods and supports improved reproductive management, early health issue detection, and overall farm efficiency. The study also addresses previous methodological gaps by validating both short- and long-term AI-based monitoring systems, contributing to more robust camel management and welfare practices.

Materials and methods

Animal housing and experimental design

This study was conducted between October 2024 and April 2025 at Bulaida Farm, Fujairah, UAE. A total of 25 healthy pregnant dromedary camels (aged 6–13 years; weight: 442 ± 51 kg; parity: 1.9 ± 1.2) were enrolled based on their known mating dates. All animals were in the 8th month of gestation or later. The camels were housed in a 60 × 50 m pen equipped with feeding and water tanks. Few days before parturition, each female was transferred to an adjacent 8 × 7 m nursery pen for close observation of the daily activities during pre- and post-parturition. The daily diet per camel included 1.5 kg wheat bran, 0.5 kg flaked maize, 0.8 kg flaked barley, and 2.0 kg dried alfalfa, with ad libitum access to Rhodes grass, fresh water, and mineral blocks. The concentrates, consisting of wheat bran, flaked maize, and barley, were divided and offered twice daily.

CCTV network layout and overlapping coverage management

A schematic layout of both pens and the CCTV network is presented in Figure 1. Four fixed high-resolution CCTV cameras (4 MP, 25× optical zoom, 25 fps, 360° rotation, 100 m infrared range) were installed in the large pen, and one camera in the nursery pen. Cameras were mounted on galvanized steel poles at a height of approximately 3.5 m and oriented to provide comprehensive coverage of all feeding and watering zones, encompassing roughly 80–90% of the total pen area. Fields of view were designed to overlap by approximately 15% to minimize blind spots and maintain continuous monitoring. Feeding utensils and water tanks were placed within the cameras' coverage zones to ensure unobstructed recording of feeding and drinking activities.

The CCTV network was configured for uninterrupted surveillance and synchronized recording across the experimental pens. Each camera covered approximately 400–500 m², with deliberate overlap between adjacent fields to enable smooth cross-zone tracking. Object detection was performed using the YOLOv8 model, while the SAMURAI tracking framework maintained consistent identity assignment across video frames. During brief occlusions (<10 s) or partial exits from a field of view, SAMURAI preserved individual identities using motion-based memory and

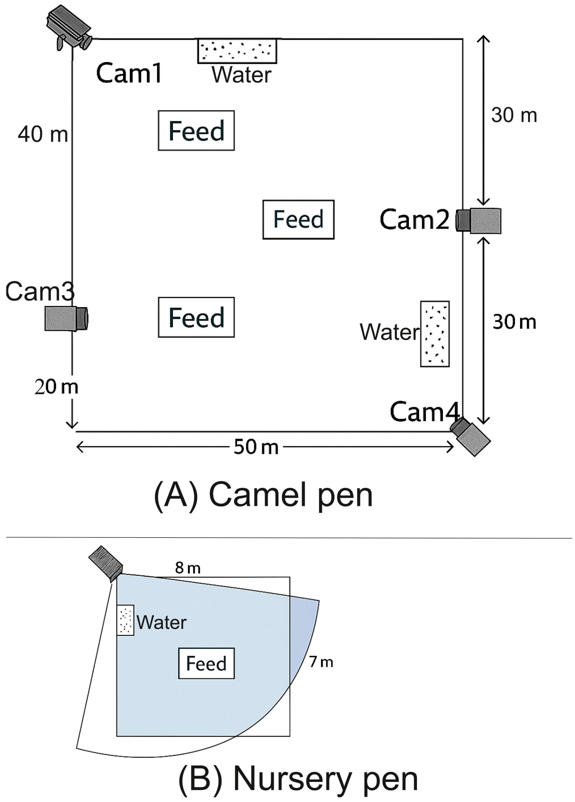

FIGURE 1
Schematic diagram of the camel pens and camera distribution. The larger pen **(a)**, measuring 60 × 50 m, houses pregnant camels and is equipped with four surveillance cameras (Cam1–Cam4) for continuous monitoring of their daily activities. Multiple feeding utensils and water sources are distributed throughout the pen. The smaller pen **(b)**, measuring 8 × 7 m, is designated for a postpartum camel and her newborn, monitored by a single camera illustrating its field of view and coverage area.

trajectory prediction. For longer occlusions or re-entries, re-identification was automatically achieved using each camel's color-coded neck collar and unique body contour. Cross-camera continuity was verified using synchronized timestamps, ensuring seamless transition of identities between overlapping cameras. Manual re-labeling was required only in rare instances of complete disappearance (>30 s).

Experiment 1: activity durations of pregnant camels at specific time intervals using SAMURAI tracking and YOLOv8-based classification

This initial experiment aimed to analyze diurnal variations in the daily activities of pregnant females on the herd-level. Conducted in October and November 2024, it included all 25 pregnant camels with gestation periods of 8–11 months. Short video recordings of 15-minute duration were collected daily at three specific time intervals: 2:00–2:15 AM (nocturnal rest), 6:00–6:15 AM (morning), and 3:00–3:15 PM (afternoon peak activity). To track individual camels during these short recordings, the SAMURAI visual tracking system was integrated with the YOLOv8n model. Bounding boxes were manually assigned to each camel in the first frame of each segment, and SAMURAI tracked each camel throughout the video using motion-aware memory and Kalman filtering. Tracked images were cropped and resized to 640 × 640 pixels before being classified by YOLOv8n into five predefined activities: eating, drinking, standing/walking, sitting, and sleeping (as detailed in the next section).

Experiment 2: automated monitoring of daily activities in pregnant, prepartum, and postpartum camels

This experiment included continuous monitoring of daily activities of 12 visibly identifiable pregnant camels, each fitted with a distinct color-coded neck collar. Observations were conducted during late gestation (between 8 and 11 months of pregnancy) over 10 non-consecutive testing days, spaced by three-day intervals, during November and December 2024. In addition, the same females were closely monitored around parturition, with each daily activity data recorded one day before and one day after parturition between January and March 2025. The expected delivery period for each female was estimated based on mating records and clinical signs of impending parturition, such as pelvic ligament relaxation, vulvar swelling, and udder enlargement

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and distension (Tibary and Anouassi, 2001). Daily camel activities were classified according to Al-Khateeb et al. (2024) into: (i) Eating, The camel remains standing with its head positioned inside the feeding tank; (ii) Drinking, same as the eating activity but its head inside the water tank; (iii) Standing/Walking, when the animal remains in upright position and/or in motion. Standing and walking were grouped together (Standing/Walking) because short walking movements often mix with standing during crowding or partial visibility.; (iv) Sitting, with all legs folded and brisket on the ground; (v) Sleeping, in either a sitting posture with the head resting on the ground, or in a lateral recumbent position with the head similarly positioned on the ground. To ensure diverse visual representation and reduce frame redundancy, non-consecutive video frames were sampled for annotation. Annotations were performed using LabelImg version 1.4.0, with manual bounding boxes and activity labels validated for accuracy. The generated CAMIC-Behav dataset was partitioned into training (70%), validation (20%), and testing (10%) sets, excluding any ambiguous frames.

Automated activity classification and multi-camel tracking framework

The YOLOv8n model was trained on the CAMIC-Behav dataset to classify the five previously defined activities. Images were resized to 640 × 640 pixels for consistency. During inference, predictions were automatically logged in CSV format, including frame number, bounding box coordinates, and classified activity. To improve temporal consistency, moving average filters were applied to reduce frame-level noise and generate coherent activity timelines.

Simultaneous multi-object tracking was achieved by assigning unique IDs to all individuals visible in the frame. Figure 2 illustrates an example of simultaneous multi-camel detection and classification, where each camel is shown with its corresponding ID and activity label (e.g., Camel_01: Standing/Walking; Camel_02: Eating; Camel_03: Sitting).

Statistical analysis

For the temporal activity analysis based on short video segments (2:00–2:15 AM, 6:00–6:15 AM, and 3:00–3:15 PM), the percentage distributions of the five activity categories were calculated and compared descriptively.

Activity durations (in minutes) were expressed as mean ± standard deviation (SD) for each activity (eating, drinking, standing/walking, sitting, and sleeping) across three experimental groups: normal pregnant, prepartum, and postpartum camels and within each group. To compare daily activity durations within each group in a specific time intervals; Midnight to early morning (00.00-06.00); Morning (6.00-12.00); Afternoon (12.00-18.00); and Evening to midnight1(8.00-00.00) and between the total 24-hour activities between the three experimental groups, a one-way analysis of variance (ANOVA) was conducted for each activity. When a significant effect was observed ($p < 0.05$), Tukey's HSD *post hoc* test was applied to determine pairwise differences among the three physiological states.

Results

Experiment 1: activity durations of pregnant camels at specific time intervals

The system used successfully maintained consistent segmentation and tracking of the selected camel across

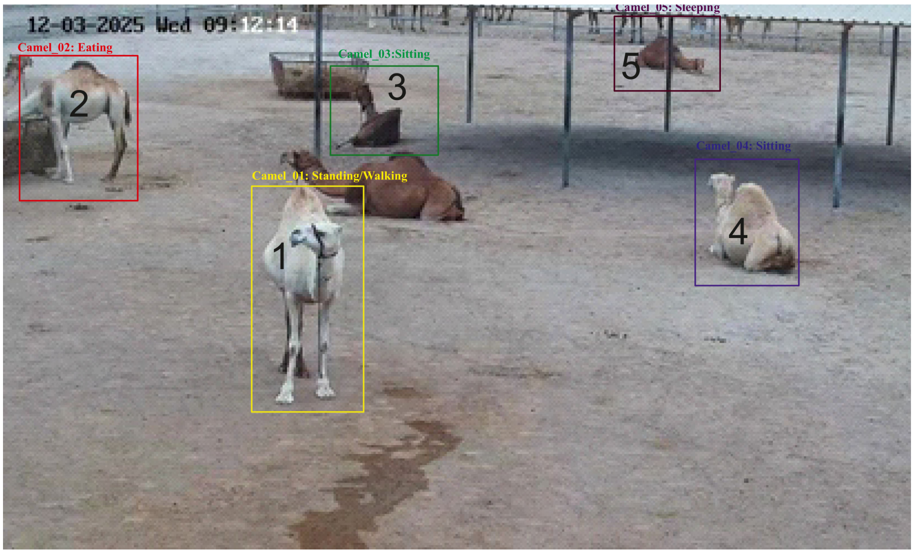

FIGURE 2
Simultaneous camel tracking and activity classification. The image illustrates real-time tracking of multiple camels using unique ID boxes and activity labels. Each camel is identified and classified according to its current activity, including standing/walking, eating, sitting, and sleeping.

subsequent frames. Accurate identification was retained at subsequent intervals and frames as shown in Figure 3, despite the presence of multiple visually similar camels within the background. The model demonstrated robust performance, correctly maintaining the camel's identity through partial occlusions and/or short exits from the field of view.

The average durations in seconds and proportions of five daily activities observed in pregnant camels at 2:00 AM, 6:00 AM, and 3:00 PM are presented in Table 1. At 2:00 AM, camels primarily engaged in resting behaviors, with sitting (360.3 ± 97.4 s, 40.0%) and sleeping (288.1 ± 71.9 s, 32.0%) dominating, while feeding and drinking were minimal. At 6:00 AM, activity levels rose, with increased standing/walking (410.0 ± 102.5 s, 45.6%) and feeding (245.2 ± 61.4 s, 27.2%), and a decrease in resting behaviors. By 3:00 PM, feeding peaked (450.0 ± 112.5 s, 50.0%), and standing/walking remained high (342.9 ± 85.7 s, 38.1%), whereas sitting and sleeping were notably reduced and each represented only 4%.

Duration of daily activities of normal pregnant camels

Pregnant camels exhibited distinct diurnal activity patterns with significant variations across different time intervals ($p < 0.05$) as shown in Table 2. Eating and drinking were significantly elevated between 06:00 and 12:00, marking this period as the peak of feeding and drinking activities (124.6 ± 23.7 min and 20.9 ± 4.9 min, respectively). Eating activity between 12:00 and 18:00 was significantly higher compared to the evening hours and the early morning period between 00:00 and 06:00 (Table 2). In contrast, resting behaviors were more dominant during the evening and night. Sitting duration was significantly higher between 18:00 and 00:00 (212.2 ± 28.5 min), while sleeping was most pronounced between 00:00 and 06:00 (157.1 ± 24.2 min), with minimal sleeping activity observed during the daytime. Standing/walking activity demonstrated a clear diurnal rhythm, with the highest levels observed during the daytime. A significant peak of standing/walking occurred between 06:00 and 12:00 (155.1 ± 10.2 min), followed by a slightly lower but still elevated duration between 12:00 and 18:00 (104.9 ± 4.4 min).

Duration of daily activities of periparturient camels

Table 3 shows the average durations of daily activities for 12 periparturient dromedary camels during the 24 hours before parturition. Standing/moving had the highest average duration (699.7 ± 145.7 min), followed by sitting (507.4 ± 97.6 min). Eating, sleeping, and drinking were recorded at 128.3 ± 48.2 min, 75.7 ± 25.0 min, and 20.9 ± 4.9 min, respectively. Eating decreased from 46.7 minutes at 12 hours prepartum to 3.4 minutes in the final hour. Drinking and sleeping also declined across the same period. Standing/walking remained relatively constant throughout the 24-hour period.

Duration of daily activities of postpartum camels

As shown in Table 4, the daily activity durations of 12 postpartum female dromedary camels were recorded over the first 24 hours following parturition. Sitting was the predominant activity, averaging 722.3 ± 75.4 minutes, followed by standing/walking (263.6 ± 29.0 minutes), eating (229.1 ± 20.9 minutes), sleeping (194.0 ± 15.4 minutes), and drinking (31.3 ± 6.3 minutes). A notable increase in activity levels was observed over time. Eating activity rose from just 4.5 ± 0.9 minutes in the first hour to 229.1 ±

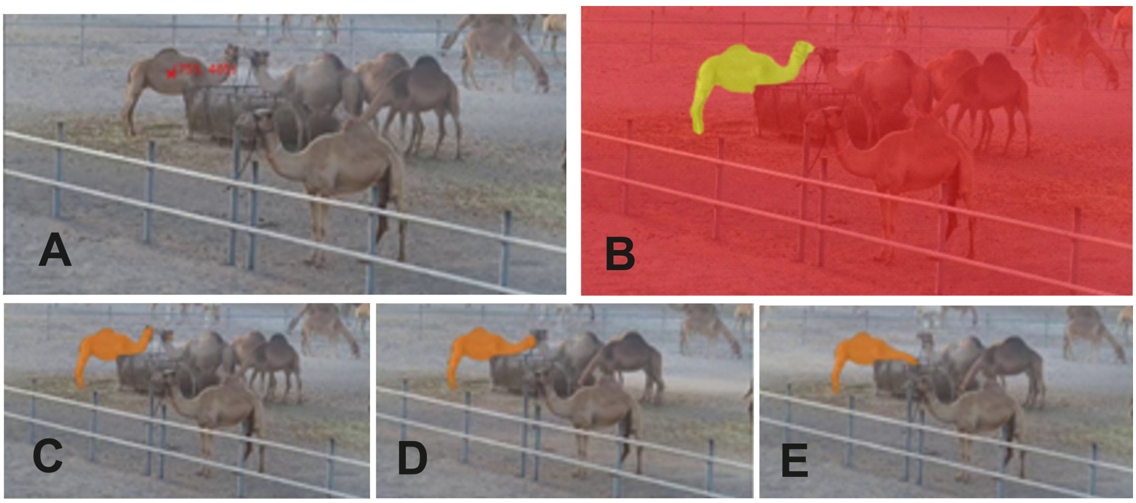

FIGURE 3
Camel tracking using the SAMURAI framework with a single-point prompt. **(a, b)** Initial point selection and the resulting segmentation mask in the first frame. **(c–e)** Accurate and consistent tracking of the same camel across frames 0, 90, and 150, respectively.

TABLE 1 Duration and percentage of daily activities of pregnant camels (n=25) at specific time intervals.

Time interval	Daily activities (time in sec/percentage)				
	Feeding	Drinking	Standing/walking	Sitting	Sleeping
02:00–02:15	18.1 ± 4.5 (2.0%)	8.9 ± 2.2 (1.0%)	224.8 ± 56.2 (25.0%)	360.3 ± 97.4 (40.0%)	288.1 ± 71.9 (32.0%)
06:00–06:15	245.2 ± 61.4 (27.2%)	26.8 ± 6.8 (3.0%)	410.0 ± 102.5 (45.6%)	185.0 ± 46.2 (20.6%)	33.0 ± 8.2 (3.7%)
15:00–15:15	450.0 ± 112.5 (50.0%)	35.1 ± 8.8 (3.9%)	342.9 ± 85.7 (38.1%)	36.6 ± 10.3 (4.0%)	36.1 ± 9.1 (4.0%)

Data are means ± SD.

20.9 minutes by the end of 24 hours. Similarly, drinking increased from 0.3 ± 0.0 to 31.3 ± 6.3 minutes, and sleeping activity rose steadily from 4.9 ± 0.5 minutes in the first hour to 194.0 ± 15.4 minutes over the full 24-hour period. This gradual increase reflects a return to normal physiological functions as the camels recovered from parturition.

Comparative analysis of daily activities between normal pregnant, periparturient, and postpartum camels

Compared to normal pregnant dromedary camels, both pre-parturient and postpartum females exhibited significant alterations in their daily activity patterns (Figure 4). Pre-parturient camels showed a marked reduction in eating (128.3 ± 48.2 min vs. 276.4 ± 40.7 min, $p < 0.05$) and drinking durations (20.9 ± 4.9 min vs. 37.2 ± 5.5 min, $p < 0.05$) in comparison to the normal pregnant females. Also, they exhibited a significant decrease in sitting and sleeping durations (507.4 ± 37.6 min vs. 596.9 ± 25.7 min, and 75.7 ± 25.0 min vs. 168.5 ± 14.5 min, respectively) and increase in standing/walking duration (699.7 ± 45.7 min vs. 360.5 ± 13.4 min, $p < 0.05$), compared to pregnant ones indicating heightened alertness or restlessness before delivery.

Postpartum camels, on the other hand, exhibited a significant increase in sitting duration (722.3 ± 65.4 min vs. 596.9 ± 25.7 min, $p < 0.05$). Although their eating and drinking durations were slightly lower than those of pregnant camels, the differences were not statistically significant. However, standing/walking activity significantly decreased in postpartum females (263.6 ± 29.0 min vs. 360.5 ± 13.4 min, $p < 0.05$), and sleeping activity duration significantly increased (194.0 ± 15.4 min vs. 168.5 ± 14.5 min, $p < 0.05$), indicating a shift toward restorative activity behaviors following calving.

Discussion

This study provides a detailed analysis of daily activity patterns in dromedary camels across some key reproductive stages, late pregnancy, pre-parturition, and postpartum, using continuous video monitoring and AI-based behavior recognition. The system integrates YOLOv8 for object detection with the SAMURAI tracking framework, enabling real-time, frame-level activity classification and individual identification in a complex farm environment. SAMURAI effectively tracked camels in 15-minute video segments without prior training or manual labeling, maintaining consistent identity even amid visual similarities, partial occlusions, and changing lighting. Built on the Segment Anything Model (SAM), it employs a motion-aware memory selection strategy that enhances mask accuracy and reduces tracking errors in visually crowded settings (Yang et al., 2024a). Its zero-shot capability supports generalization across environments without retraining, making it ideal for practical livestock monitoring. These findings align with broader trends in automated animal monitoring, where similar AI tools have been applied in cattle (Yamsani et al., 2024) and fish detection and their counting in water through video analysis (Khiem et al., 2025). The integration of segmentation models like SAMURAI represents a significant advancement in scalable, contactless precision farming technologies (Scott et al., 2024). Thus, the YOLOv8–SAMURAI system offers a reliable, non-invasive solution for monitoring camel

TABLE 2 Duration in minutes of the daily activities for pregnant camels (n=12) during the daily hours for 10 non-consecutive days.

Time	Daily activities				
	Eating	Drinking	Standing/walking	Sitting	Sleeping
00.00–06.00	16.7 ± 3.5 [c]	2.2 ± 0.7 [c]	37.6 ± 5.6 [c]	140.3 ± 22.7 [b]	157.1 ± 24.2 [a]
06.00–12.00	124.6 ± 23.7 [a]	20.9 ± 4.9 [a]	155.1 ± 10.2 [a]	53.0 ± 11.4 [c]	8.2 ± 3.0 [c]
12.00–18.00	92.8 ± 17.8 [a]	6.9 ± 1.8 [b]	104.9 ± 4.4 [a]	141.4 ± 15.7 [b]	10.3 ± 5.2 [c]
18.00–00.00	42.3 ± 15.1 [b]	7.2 ± 2.4 [b]	62.9 ± 9.1 [b]	212.2 ± 28.5 [a]	43.2 ± 11.3 [b]
Total	276.4 ± 40.7	37.2 ± 5.5	360.5 ± 13.4	596.9 ± 25.7	168.5 ± 14.5

Data are means ± SD.
Data are marked with different letters in the same column are significantly different (p < 0.05).

TABLE 3 Average duration of daily activities of pre-parturient female dromedary camels (n=12).

Time	Daily activities				
	Eating	Drinking	Standing/walking	Sitting	Sleeping
1 h	3.4 ± 1.8	0.6 ± 0.3	28.4 ± 10.0	31.7 ± 8.7	2.2 ± 0.8
2 h	6.2 ± 3.2	0.7 ± 0.9	70.9 ± 22.2	74.3 ± 16.2	12.7 ± 6.5
6 h	19.6 ± 8.1	2.7 ± 1.7	166.8 ± 33.5	162.3 ± 23.2	24.2 ± 8.5
12 h	46.7 ± 14.2	13.9 ± 2.6	330.1 ± 53.2	292.6 ± 42.2	44.6 ± 18.5
24 h	128.3 ± 48.2	20.9 ± 4.9	699.7 ± 45.7	507.4 ± 37.6	75.7 ± 25.0

Data are means ± SD.

TABLE 4 Average duration of daily activities of postpartum female dromedary camels (n=12).

Time	Daily activities				
	Eating	Drinking	Standing/walking	Sitting	Sleeping
1 h	4.5 ± 0.9	0.3 ± 0.0	14.8 ± 4.6	35.1 ± 2.9	4.9 ± 0.5
2 h	18.3 ± 1.9	0.6 ± 0.1	30.4 ± 3.0	63.5 ± 5.9	9.8 ± 1.0
6 h	48.1 ± 5.8	5.0 ± 0.5	65.5 ± 8.5	213.9 ± 17.4	27.6 ± 3.8
12 h	98.5 ± 11.9	14.8 ± 2.0	138.9 ± 17.1	405.4 ± 33.5	66.3 ± 7.5
24 h	229.1 ± 20.9	31.3 ± 6.3	263.6 ± 29.0	722.3 ± 65.4	194.0 ± 15.4

Data are means ± SD.

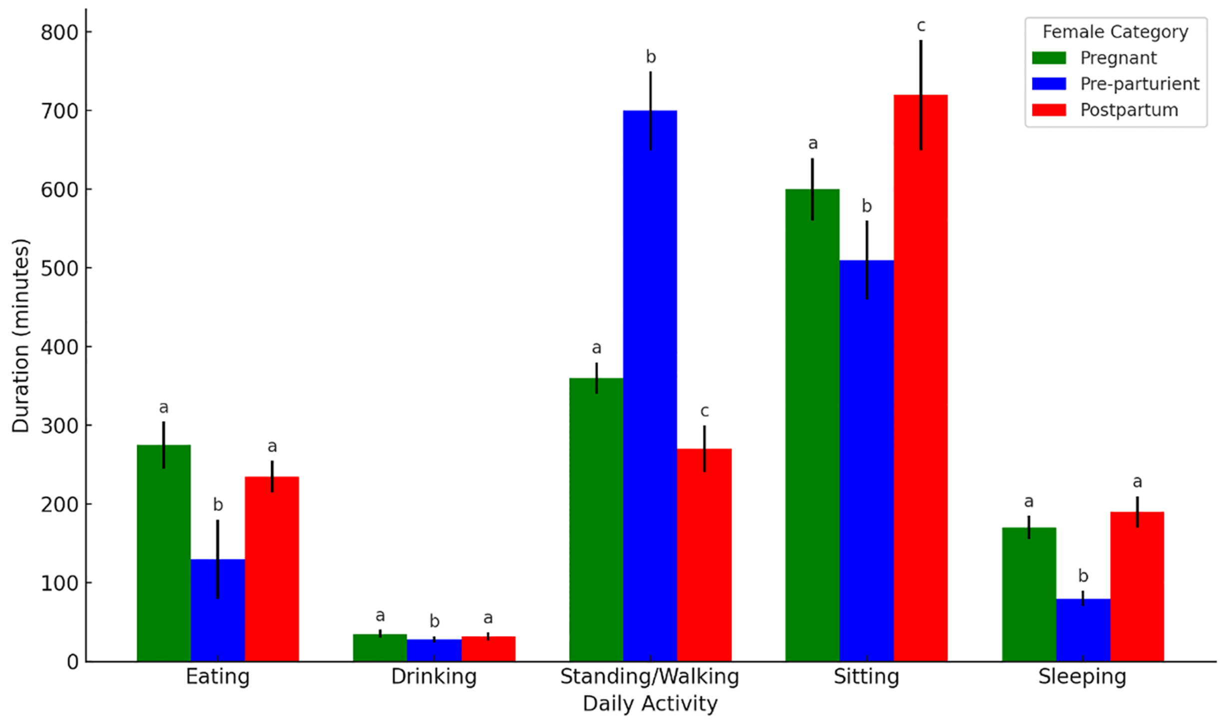

FIGURE 4
Comparison of 24-hour activity durations between normal pregnant, pre-parturient and post-parturient female camels. Error bars represent standard deviations. Different superscript letters (a-c) indicate statistically significant differences (*p* < *0.05*).

behavior, with potential applications in reproductive management, early health detection, and farm efficiency. However, this study evaluated the system over short video intervals, and further validation using long-term recordings is needed to confirm its robustness and practical utility.

The present multi-camera system ensured full visual coverage and reliable individual identification within large open pens. The use of overlapping CCTV fields, combined with color-coded collars, effectively reduced identity switching and eliminated blind zones. These design principles are consistent with multi-camera livestock monitoring systems reported for cattle (Crociati et al., 2022) and pigs (Yang et al., 2024b), highlighting the scalability of this approach to larger animal herds with more complex housing layouts.

Temporal analysis at 2:00 AM, 6:00 AM, and 3:00 PM provided further validation of the camels' circadian regulation. At 2:00 AM, the predominant activities were sitting and sleeping (70% of activity), while 6:00 AM marked a sharp transition to standing/walking feeding, and drinking activities. At 3:00 PM showed a peak in feeding (75.0 ± 4.6 min) with continued active movement. The increase in daily activity during early morning including standing/walking, eating and drinking activities agree with previous studies on immature camels (Al-Khateeb et al., 2024) and on lactating camels (Aoun et al., 2024). Additionally, the predominate sitting and sleeping activities at 2:00 AM indicated the diurnal activity of the camels. Generally, camels have documented diurnal activity rhythms when the locomotor activity started early in the photo phase and then reached its peak in the middle of the day around 12:50 h (Farsi et al., 2020). Similar activity patterns are noted also in immature and in male camels, where inactive behaviors like lying down, either in sitting and sleeping, peak during the evening and nighttime, whereas active activities such as feeding, walking, and stereotypical movements are most prevalent during daylight hours (Aubè et al., 2017; Al-Khateeb et al., 2024).

The second experiment's employment of color-coded neck collars facilitated continuous, long-term identification and monitoring, significantly enhancing the reliability of activity data over extended periods. This method proved particularly useful in observing subtle, yet crucial temporal activity variations associated with the reproductive states of camels. Our findings are aligned with earlier research that highlighted the importance of continuous behavioral monitoring for improved swine welfare and efficient management in intensive farming conditions (Yang et al., 2024b). In pregnant camels, sitting and standing/walking were the dominant activities, averaging 596.9 ± 25.7 minutes/day and 360.5 ± 13.4 minutes/day, respectively. These findings reflect a clear diurnal rhythm in activity patterns, with increased activity during daylight hours and predominant resting at night, like the activity range observed in non-pregnant and lactating camels (Al-Khateeb et al., 2024; Aoun et al., 2024). Feeding activity was most prominent during the daylight period, particularly in the morning hours, while sleeping activity was concentrated at night, suggesting clear circadian regulation. Eating and drinking peaked between 06:00 and 12:00, coinciding with the highest levels of standing/moving activity and lower periods of sitting and sleeping. A slight decrease in eating was noted during the afternoon. From 18:00 to 06:00, the main activities shifted to sitting and sleeping. Sitting peaked during the evening until midnight, while sleeping reached its highest levels from midnight until early morning. These activity patterns are consistent with previous observations in camels, which demonstrate strong diel activity patterns influenced by ambient temperature, light exposure, and feeding cycles (Farsi et al., 2020). Dromedary camels in their natural habitat, camels spent a plenty of their time walking in search of food, water, and shade at the expense of some resting activities such as lying and sleeping (Fesseha and Desta, 2020). Moreover, similar baseline patterns in non-stressed dairy cows suggest that extended standing and feeding periods when within physiological limits are indicative of positive welfare status and homeostasis (DeVries et al., 2004; Andriamasinoro et al., 2016).

The periparturient phase in dromedary camels was marked by a pronounced shift in activity patterns. Standing/walking time increased significantly to 692.3 ± 145.7 minutes/day, while both feeding and sleeping durations declined to 128.3 ± 48.2 minutes/day and 85.7 ± 25.0 minutes/day, respectively. These changes reflect a pattern of restlessness and discomfort typically observed in the hours leading up to parturition (Mansour et al., 2024; Tibary and Anouassi, 2001). The reduction in feeding and sitting, combined with prolonged standing/walking, is likely associated with uterine contractions and abdominal pain experienced during the first and second stages of labor. Such behavioral alterations have been consistently observed in camels within the 24 hours preceding calving (Hammadi et al., 2021a; Mansour et al., 2024). These findings are consistent with observations in dairy cattle, where the pre-calving period is also characterized by increased standing time, reduced feed intake, shorter and more frequent lying bouts, and restlessness attributed to pain or changing motivational states (Huzzey et al., 2005; Miedema et al., 2011; Proudfoot et al., 2013; Crociati et al., 2022).

In postpartum dromedary camels, a clear recovery in activity patterns were observed over the 24-hour period following calving. Most notably, sitting time significantly increased to 722.3 ± 65.4 minutes/day, indicating a return to a restorative resting pattern. Feeding activity also progressively increased, reaching 229.1 ± 20.9 minutes/day by the end of the first 24 hours, reflecting the gradual re-establishment of energy balance and maternal-offspring bonding. This recovery trend parallels findings in early postpartum ewes and dairy cows, where increased lying or sitting time and cautious movement are associated with physical recuperation, pain alleviation, and the onset of maternal behavior (Dwyer and Lawrence, 2000; von Keyserlingk and Weary, 2007). Sleeping activity, recorded at 194.0 ± 15.4 minutes/day, was slightly reduced compared to the normal pregnancy phase. This moderate reduction may reflect a state of heightened vigilance or residual alertness, possibly associated with the need to protect and monitor the newborn calf, a behavior also reported in postpartum cattle (Lidfors et al., 1994; Jensen, 2012). These patterns emphasize the importance of minimizing disturbances during the early postpartum phase to support effective maternal bonding, behavioral normalization, and physiological recovery. In cattle, similar recommendations are made based on evidence that excessive human intervention or environmental disruption during this period may negatively affect cow-calf interaction, milk let-down, and maternal behavior establishment (Costa et al., 2016).

Key behavioral transitions identified in this study such as the prepartum increase in standing/walking and decline in feeding, as well as the postpartum rise in resting and feeding activities represent reliable indicators for anticipating calving events, evaluating maternal recovery, and detecting early health deviations. These behavioral markers are particularly valuable in arid-region camel farming systems, where continuous veterinary oversight may be limited. To further enhance the utility of automated monitoring tools, future research should focus on extending behavioral classification to include social interactions, calf-care behaviors, and early signs of subclinical illness. Additionally, the integration of physiological data from thermal imaging or biometric sensors, along with validation across different breeds, seasons, and housing systems, will support broader adaptation of AI-based behavioral monitoring technologies in precision camel farming.

Conclusion

This study highlights the value of computer vision and deep learning, specifically YOLOv8 with SAMURAI, for non-invasive, continuous monitoring of camel behavior under intensive farming. These tools enhance reproductive management and welfare assessment. Future research should expand behavioral classification, integrate physiological data, and validate the system across longer periods and conditions to support broader adoption in precision camel farming.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The animal studies were approved by Fujairah Research Centre committee with approval from the responsible ministry. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent was obtained from the owners for the participation of their animals in this study.

Author contributions

NM: Investigation, Methodology, Formal Analysis, Visualization, Writing – original draft. FA: Writing – original draft, Validation, Investigation, Methodology. HC: Formal Analysis, Methodology, Investigation, Writing – review & editing, Conceptualization. MN: Methodology, Validation, Writing – original draft, Investigation, Resources. FL: Resources, Project administration, Investigation, Methodology, Writing – review & editing.

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Conflict of interest

Author MN was employed by company Bulaida Farms, Raibal Group.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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