Research Article

Evaluation of Rumination and Milk Yield Alerts Utilizing SCR System for Mastitis, Ketosis, and Abomasal Displacement on the Dairy Cow Farm in Vietnam

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Abstract | This study was conducted on the dairy cow farm in Gia Lai Province, Vietnam, from June 2022 to June 2023 using SCR chips and analyzing by DataFlow™ II management software. SCR chips were implanted in cow's necks to monitor their rumination indexes and physical activities. Based on rumination time and milk yield data, the alerts of Health–milked from cows HIS < 75 units were reported daily. Of 250 cows 0-90 days of milking, 205 cows had at least one disease, and 45 were healthy. The SCR system sensitivity was 58.33%. Rumination alerts recorded 345 alerts, including 203 alerts of diseases after clinical examination, in which abomasal displacement was 100% alert effective, ketosis at 73.53% alerts, and mastitis at 63.83% alerts. However, the rates of mastitis, ketosis, and abomasal displacement were 24%, 13.6%, and 10%, respectively. On the alert day, rumination time and milk yield of diseased cows were lower than those of non-diseased cows (P<0.05). Rumination time and milk yield decreased markedly on the alert day compared to 7 days before the alert in diseased cows (P<0.01), while milk production did not change in non-diseased cows (P>0.05). The HF breed had more variation in rumination time than HFxJS, while milk yield was affected more in HFxJS. The parity also affected rumination time and milk yield. SCR systems monitored rumination time and milk yield to identify health disorders and support early diagnosis of mastitis, ketosis, and abomasal displacement in the dairy cow farm.

Keywords | Alerts, Dairy cows, Milk yield, Rumination, SCR systems

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INTRODUCTION

The dairy cow industry in Vietnam has been growing with large-scale farms, so monitoring the health status of each dairy cow requires substantial human resources. To enhance the sustainability of dairy cattle production, making national and on-farm investments in dairy cattle health is crucial. These investments include implementing biosecurity regulations and ensuring their enforcement, administering vaccines and medicines, and monitoring the herd's overall health (Capper and Williams, 2023). Thus, new technologies have been applied in farming to reduce human labor and monitor cattle health effectively.

Different information technologies have enabled breeders to effectively collect reliable data on individual cows in their herds and closely monitor changes in cow behavior, which act as indicators for alterations in their physiological statuses (Tekin *et al*., 2021). SCR chip technology offered a viable alternative to direct eye observation (Schirmann *et al*., 2009). The SCR system recorded data, including identification, activity index, ruminant index, milk yield, and other parameters of dairy cow health. The results of statistical reports helped to recognize health disorders and risk of diseases in cows; therefore, farmers had timely intervention, and early treatments would decrease economic loss affected by fertility, milk yield, and quality. Moreover, the SCR dataflowTM II system is an advanced herd management solution designed to enhance the productivity of dairy farmers and milking operators. By offering a range of powerful management tools such as reports, graphs, analytics, task lists, and cow histories, this system enables users to work more efficiently and make informed decisions. Dataflow™II software allowed the diseases in dairy cows to be detected several days before clinical symptoms (Stangaferro *et al*., 2016). In Vietnam, Diep *et al*. (2022) used the American SCR tracker to check the locomotion and rumination of cows in dairy farms in Ho Chi Minh City in ketosis cows. However, no reports have been published regarding the valuable use of this technology in predicting and diagnosing diseases in dairy cattle in Vietnam.

When new technologies were applied, health alerts were built based on changes in rumination, activity indexes, and milk yield. The relationship between behavior and productivity varies depending on the health disorder, indicating the ability to differentiate between health issues (King *et al*., 2017). Previous research showed that health disorders in the early postpartum have been reported when the rumination in the day decreases (Calamari *et al*., 2014; Sterrett *et al*., 2014; Liboreiro *et al*., 2015; Paudyal *et al*., 2018). Besides, cows were infected ketosis, their HIS (Health Index Score) was under 74 units on the alert day and also one day after the alert day (Stangaferro *et al*., 2016). Moreover, the rumination alerts and HIS were reported for health disorders after calving, especially three critical diseases including mastitis, ketosis, and abomasal displacement (Doron and Ran, 2010; Calamari *et al*., 2014; Sterrett *et al*., 2014; Liboreiro *et al*., 2015; Paudyal *et al*., 2018). In addition, decreasing rumination also appeared when dairy cows had clinical mastitis (Fitzpatrick *et al*., 2013; Siivonen *et al*., 2011). At the peak of milk yield with DIM 0-90 days, we recognized mastitis, ketosis, and abomasal displacement affected the most health status, productivity, and milk yield in dairy cow farms. Cook *et al*. (2023) reported that the transition alert could be used to predict postpartum disease treatments using a commercial monitoring system. In addition, associations were identified between postpartum health and production outcomes and prepartum behavioral measures from an automated activity monitoring system. Antanaitis *et al*. (2019) used the Hi-Tag rumination monitoring system (SCR) for cow health monitoring after surgical treatment for the left displacement of the abomasum. Therefore, utilizing automatic monitoring systems, including the SCR system, is essential and effective for controlling the health of dairy cattle on farms, especially in common diseases such as mastitis, ketosis, and abomasal displacement.

Until now, modern technologies to analyze the correlation between the rumination index and risks of these diseases in dairy cows after calving have not been studied much in Vietnam. Therefore, this study aimed to evaluate the effects of rumination alerts of DataFlow™ II-SCR systems on mastitis, ketosis, and abomasal displacement. From that, the health condition of dairy cattle could be managed, and diseases could be prevented early.

MATERIAL AND METHODS

Time and place, experiment animals

The study was conducted on a dairy cow farm from June 2022 to June 2023 in Gia Lai Province, Vietnam. As presented in Table 1, there were 50 cows without any alerts and diseases in control group.

Table 1: Cows in control group from 0 – 90 days in milk.

Breed	Parity 1	Parity 2	Parity 3	Parity 4	Parity 5	Total
HF (n) (x̄± SD, minute/day)	5 525.89 ± 83.87	5 503.77 ± 107.74	5 530.88 ± 74.34	8 521.19 ± 78.46	7 526.37 ± 91.90	30 521.89 ± 87.78
HF x JS (n) (x̄± SD, minute/day)	5 537.14 ± 90.64	6 514.23 ± 99.55	6 518.78 ± 102.21	3 558.48 ± 85.06	0	20 527.96 ± 97.34
Total (n) (x̄± SD, minute/day)	10 531.52 ± 87.45	11 509.48 ± 103.43	11 524.28 ± 90.77	11 531.36 ± 81.97	7 526.37 ± 91.90	50 524.32 ± 91.76

The experience group included 250 dairy cows in Table 2, which had ruminant alerts, were randomly selected in each breed to observe in this experiment. Milking cows from 0 to 90 days after calving were implanted with SCR chips to record and analyze the data using DataFlow™ II-SCR software.

Table 2: Cows had alerts from 0–90 days in milk.

Breed	Parity 1 (cow)	Parity 2 (cow)	Parity 3 (cow)	Parity 4 (cow)	Parity 5 (cow)	Total (cow)
HF	24	38	35	39	26	162
HF x JS	26	12	15	11	24	88
Total	50	50	50	50	50	250

Breeding conditions

Dairy cows were raised in a free stall barn, with cooling systems and a mist sprayer installed at the cow's feeding. The mist lasted 3 minutes, lasting 20 seconds/time with ceiling fan systems. Feces and urine were automatically scraped by machines 24/24 hours and collected into the manure pits. Water drinking was arranged in the barn. Depending on the periods of days in milk and pregnancy in dairy cows, the total mixed ration silage was calculated based on nutritional requirements. Cows were milked thrice daily, at 5:00 am, 1:00 pm, and 9:00 pm.

Food ration includes Mombasa grass, Alfafa hay, Seedmix grass, fresh corn, straw, corn silage, corn powder, soybean meal, wheat grain, barley, cotton seed, organic vitamin premix, grain salt, wort beer. Depending on the physiological stage, TMR (Total Mixed Ration) feed is calculated to suit the nutritional needs of each group of cows. Feed spread 3 times/day according to milking times.

Collecting data

Rumination patterns and HIS were evaluated along with the clinical diagnosis of health disorders were conducted in the study, including abomasum deviation, ketosis and mastitis, which are three important diseases of cows after giving birth (Doron and Ran, 2010; Calamari *et al*., 2014; Sterrett *et al*., 2014; Liboreiro *et al*., 2015; Paudyal *et al*., 2018) and 3 months after birth when cows reach the milk peak. Thus, the observation was done at DIM 0-90 days.

The effectiveness of health warnings was evaluated using the results of clinical diagnosis by farm veterinarians as a reference.

SCR chips were implanted in cows' necks when they were about 12 months old to monitor their rumination indexes and physical activities. Based on rumination time and activity, the system's software creates an HIS index for each cow. HIS consists of 100 units, and HIS value ≤ 86 units is a warning of health disorders. Data were recorded every 2 hours. Data from the chips were automatically transferred to Dataflow every 20 minutes through antennas in the barn. Based on activities, rumination, and milk yield data, the alerts of Health–milked cows reports were generated daily from the SCR system with cows' HIS (Health index score) < 75 units.

The data were collected from 250 dairy cows in Table 2 with the following criteria:

- Parity 1-5; breed Holstein Friesian (HF) and hybrid of HF x Jersey (HFxJS); 0-90 DIM.
- Health index score (HIS): the changes in rumination and movement of cows compared to the previous days. Based on these data, the system's software generated an HIS index for each cow using a series of algorithms – proprietary to SCR Dairy. HIS consisted of 100 units representing an ideal rumination and function index if HIS value < 75 units were reported as an alert of health disorders.
- The rumination index was the time of rumination for 24 hours. Rumination was measured with the SCR chip on the cow's necklace to record the distinctive sounds of burping and rumination. Data were calculated and summarized every 2 hours, stored in memory, and transferred to software for data processing (DataFlow software, SCR Engineers Ltd.). The ruminant data were collected and calculated the daily ruminantion index by adding up data from 8 a.m. to 8 a.m. the next day. The average rumination time in healthy cows (459.2 minutes/day) was higher than this in diseased cows (335.2 minutes/day) (Paudyal *et al*., 2018), so when cows had a lower rumination index than the average normal values of the previous days, cows needed health checks.
- Milk yield meant the milk yield produced for 24 hours was automatically recorded on the milking platform (unit: kg/day).

$$\text{Diseased rate (\%)} = \frac{(\text{Number of diseased cows}) \times 100}{(\text{Number of cows surveyed})}$$

$$\text{Alert rate (\%)} = \frac{(\text{Number of diseased cows with alert}) \times 100}{(\text{Number of cows surveyed})}$$

Clinical examination and health disorders

- Mastitis: subclinical examination using the California Mastitis Test (CMT) method (McFadden, 2011).
- Ketosis: The cows had decreased appetite (recording the amount of feed, the time of eating, and rumination after milking), checked ketosis by urine test strips (KetoStix, Bayer Diagnostics, Tarrytown, NY), and recorded milk yield. Levels (based on concentration of acetoacetate) include negative: AcAc < 0.5; has trace AcAc = 0.5 (490 µmol AcAc/L, shown as 5 mg/Dl on the scale); low AcAc = 1.5 (1470 µmol/L or 15mg/Dl);

average AcAc = 4 (3920 µmol/L or 40 mg/Dl); and high AcAc = 8 (7840 µmol/L or 80 mg/Dl) and high AcAc = 16 (15,700 µmol/L or 160 mg/Dl) (Carrier *et al*., 2004).

- Abomasal displacement: the abomasum moved to an abnormal position on the right or left of the abdominal cavity and was detected by percussion and listened to a "ping" sound by a stethoscope.

Cows with the above health disorders in this study were monitored daily until recovery. Two consecutive occurrences of the same disorder were evaluated separately when occurring at least 7 days apart, followed up to 90 days of lactation.

The dairy cows were complied with the procedures of the Animal Welfare Council, Nong Lam University, Ho Chi Minh City, Vietnam.

Statistical analysis

Data were collected and tracked from DataFlow™ II software information of the SCR system according to the form and processed to analyze by Pearson Chi-square test using Minitab version 17.0 at 95% of confidence level.

RESULTS AND DISCUSSION

The alert efficiency of the SCR system

SCR systems identified indicators such as rumination time, milk yield, activity, and other information, including date of birth, group batch, and reproductive status by DataFlow™ II software. A health alert was reported by the health index score based on changes in rumination time and milk yield. The rumination time recorded from 5 days before calving to 0-90 DIM in dairy cows was represented in Figure 1.

The healthy cows reached a HIS index value of 100 units. Stangaferro *et al*. (2016) showed that health alerts occurred with HIS ≤ 75 and alert system sensitivity at 59% in cows. Rumination time was reduced every 50 minutes/day, and the HIS decreased by 1 point; when the milk yield dropped, the HIS also reduced. Stangaferro *et al*. (2016) observed a decline in HIS when cows reduced rumination time below the threshold level in abomasal displacement or ketosis. In contrast, HIS did not decrease in cases of mastitis. The other studies also indicated that cows suffering from mastitis, ketosis, or abomasal displacement reduced rumination time and milk yield (Soriani *et al*., 2013; Gáspárdy *et al*., 2014; Stangaferro *et al*., 2016; Paudyal *et al*., 2018).

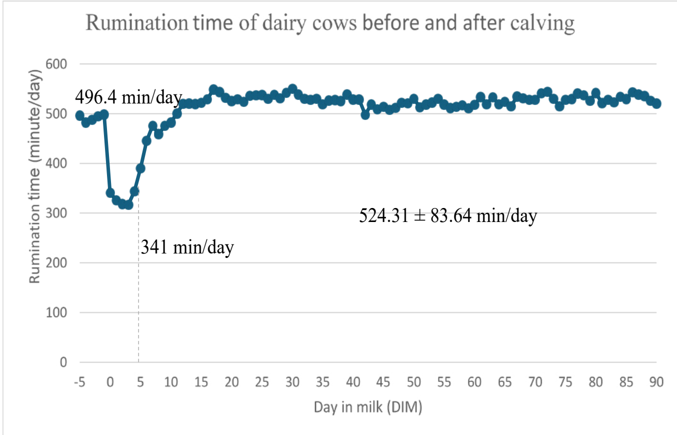

Figure 1: Rumination time of dairy cows before and during 90 DIM after calving.

The study recorded 345 alerts from 250 postpartum cows with an HIS value under 75. However, only 203 alerts indicated diseases occurred in cows; the alert efficiency of the SCR system was pretty low at 58.33% in our study. According to Stangaferro *et al*. (2016), health alerts occurred with sensitivity at 59% in dairy cow herds. The results of alert effectiveness showed that abomasal displacement had the highest rate at 100%, was relatively effective for ketosis (73.53%), and was less accurate in mastitis (63.83%) (Table 3). Stangaferro *et al*. (2016) also showed similar results, with alert rates of 99%, 91%, and 58% for abomasal displacement, ketosis, and mastitis, respectively. The difference was influenced by disorder status and disease levels. Abomasal displacement might be diagnosed in cows that had ketosis before (LeBlanc *et al*., 2005). SCR system was useful to diagnosis early diseases and health status in dairy cows, however the results indicated that some cows having alerts but not got any diseases after examination. So, cows were alerted that they needed to do clinical examinations carefully to identify disease status.

The rumination time and milk yield in dairy cows received alerts from SCR system

The results showed that on the alert day, the rumination time of diseased cows (209.69 minutes/day) was lower than that of non-diseased cows (256.40 minutes/day) (P< 0.05) (Table 4). Comparing with cows in control group, the average rumination time was 524.32 minutes/day (Table 1).

Table 3: The percentage of disease and alert in mastitis, ketosis, and abomasal displacement.

Disease	n	Diseased cows (cow)	Diseased rate (%)	Diseased cows, according to the alert (cow)	Alert rate (%)	Alert effective (%)
Mastitis	250	94	37.6	60	24.0	63.83
Ketosis	250	34	13.6	25	10.0	73.53
Abomasal displacement	250	25	10.0	25	10.0	100

Table 4: Rumination time and milk yield of dairy cows on alert days.

Parameters	Diseased cows	Non-diseased cows	P value
Alert (n)	203	142	
Rumination time ($\bar{x}$±SD, minute/day)	209.69 ± 142.07	256.40 ± 18	0.002
Milk yield ($\bar{x}$±SD, kg/day)	14.55 ± 6.99	19.32 ± 8.59	0.000

Table 5: Rumination time and milk yield of diseased cows before and on the alert day.

Parameters	Group	Alert (n)	7 days before the alert ($\bar{x}$±SD)	Alert day ($\bar{x}$±SD)	P value
Rumination time (minute/day)	Diseased	203	440.15 ± 119.11	209.69 ± 142.07	0.000
	Non-diseased	142	470.7 ± 80.7	256.4 ± 147.0	0.000
	Total	345	452.71 ± 105.95	228.90 ± 145.75	0.000
			P = 0.002		
Milk yield (kg/day)	Diseased	203	17.93 ± 10.37	14.56 ± 6.99	0.000
	Non-diseased	142	19.20 ± 11.13	19.32 ± 8.59	0.819
	Total	345	18.45 ± 10.69	16.52 ± 8.03	0.000
			P = 0.000		

On alert day, the milk yield of diseased cows (14.55 kg/day) was lower than that of non-diseased cows (19.32 kg/day) (P < 0.01) (Table 4). This difference in milk yield between the two groups indicated that milk production was not affected by alert in non-diseased cows. When an alert occurred, rumination times were decreased in two cow groups on alert days. However, comparing average rumination times of seven days before the alert recorded 440.15 minutes/day, rumination times were decreased on the alert day (209.69 minutes/day (P < 0.01) (Table 5). Similarly, the rumination time of 7 days before the alert was 470.70 minutes/day in the non-diseased cow group and decreased on the alert day at 147 minutes/day (P < 0.01). Regarding milk yield in diseased cows, milk production 7 days before the alert was 17.93 kg/cow and reduced on the alert day (14.56 kg/cow) (P < 0.01). The interesting thing in non-diseased cows was that the milk yield 7 days before the alert was 19.197 kg/cow and did not change on the alert day (19.316 kg/cow) (P > 0.05). The results in Tables 4 and 5 showed that the change in rumination time before and on the alert day between the diseased and non-diseased cow groups tended to decrease. However, milk production before and on the alert day only decreased in the diseased cow group and no change in the non-diseased one. Thus, cows had a higher disease risk from alerts, and milk yield decreased more than rumination time.

Stangaferro *et al.* (2016) indicated that rumination times of cow's mastitis were 291 to 397 minutes/day, and milk yields ranged from 6.9 to 12.8 kg/day on the alert day. Reducing milk yield was directly attributed to the inflammatory condition of the mammary gland (Akers and Nickerson, 2011). Moreover, cows suffering from metabolic and digestive disorders might produce less milk due to reduced feed intake and the overall impact of the illness on their health (Van Winden *et al.*, 2003). Gonzalez *et al.* (2008) demonstrated significant changes in eating behavior before and after ketosis. However, the rumination time remained high at 369.9 minutes/day in ketosis but lower than in healthy cows (Liboreiro *et al.*, 2015). Talukder *et al.* (2015) showed that in a cow identified with abomasal displacement, rumination time was 240 minutes/day, and milk yield significantly decreased by 8 kg/day lower than that of healthy cows. The study presented functional parameters of rumination time and milk yield to diagnose mastitis, ketosis, and abomasal displacement, and this was meant to offer helpful screening methods in dairy cow herds.

The rate of mastitis, ketosis, and abomasal displacement from dairy cows received alerts

The results, based on rumination time and milk yield of alert cows, showed that cows had alerts, but they were not diseased; their milk yields were still high and, compared with the milk yield average of the previous week, were not different. The clinical examination results indicated that alert cows had decreased both rumination time and milk yield; they had a high risk of diseases. The results of clinical examinations and diagnosis after alerts were divided into diseased groups in Figure 2.

The highest rate of the diseased group was mastitis at 23% (Figure 2). Mastitis was a common and vital disease affecting milk yield and quality in dairy cows. The results showed two other common diseases in herds were ketosis and abomasal displacement, with 13% and 10%, respectively (Figure 2). The incidence of ketosis (13.6%) was lower than other diseases (22.7%) (Chanakarn *et al.*, 2022).

Table 6: Rumination time before and on alert days for mastitis, ketosis, and abomasal displacement analyzed by breed.

Disease	Breed	n	Data	7 days before the alert	Alert day	P
Mastitis	HF	66	Rumination time (x̄±SD, minute/day)	481.1 ± 117.7	332.9 ± 187.5	0.000
			Milk yield (x̄±SD, kg/day)	26.84 ± 56.33	14.45 ± 8.53	0.085
	HF×JS	28	Rumination time (x̄±SD, minute/day)	504.6 ± 69.7	346.3 ± 193.2	0.000
			Milk yield (x̄±SD, kg/day)	16.79 ± 12.33	13.47 ± 10.47	0.010
	Subtotal	94	Rumination time (x̄±SD, minute/day)	488.1 ± 336.9	105.9 ± 188.3	0.000
			Milk yield (x̄±SD, kg/day)	23.85 ± 47.78	14.16 ± 9.10	0.055
Ketosis	HF	22	Rumination time (x̄±SD, minute/day)	412.7 ± 127.7	327.3 ± 180	0.036
			Milk yield (x̄±SD, kg/day)	17.94 ± 5,98	20.22 ± 4.12	0.077
	HF× JS	12	Rumination time (x̄±SD, minute/day)	350.6 ± 107.4	249.0 ± 140.7	0.053
			Milk yield (x̄±SD, kg/day)	16.43 ± 5.25	16.29 ± 4.52	0.905
	Subtotal	34	Rumination time (x̄±SD, minute/day)	390.8 ± 123.0	299.7 ± 169.3	0.004
			Milk yield (x̄±SD, kg/day)	17.41 ± 5.7	18.83 ± 4.61	0.124
Abomasal displacement	HF	19	Rumination time (x̄±SD, minute/day)	385.8 ± 147.6	144.1 ± 94.8	0.000
			Milk yield (x̄±SD, kg/day)	16.65 ± 9.20	14.26 ± 5.8	0.088
	HF× JS	6	Rumination time (x̄±SD, minute/day)	333.7 ± 80.4	197.7 ± 102.8	0.064
			Milk yield (x̄±SD, kg/day)	15.17 ± 8	11.78 ± 6.1	0.050
	Subtotal	25	Rumination time (x̄±SD, minute/day)	373.3 ± 134.9	157 ± 97.4	0.000
			Milk yield (x̄±SD, kg/day)	16.30 ± 8.79	13.67 ± 5.84	0.019

Ketosis could lead to significant economic losses, such as reducing milk production by 1.0-1.4 kg/day (Dohoo and Martin, 1984), changing milk composition, increasing the risk of other diseases, and decreasing reproductive performance (Raboisson *et al.*, 2014). According to the U.S. Department of Agriculture (2017), the prevalence of abomasal displacement in dairy herds was approximately 3.5%, including 2.5% in a herd population of more than 500 cows and 4.8% in herds of less than 500 cows. In well-managed dairy farms, the goal was less than 3% of cows with abomasal displacement (Caixeta *et al.*, 2018).

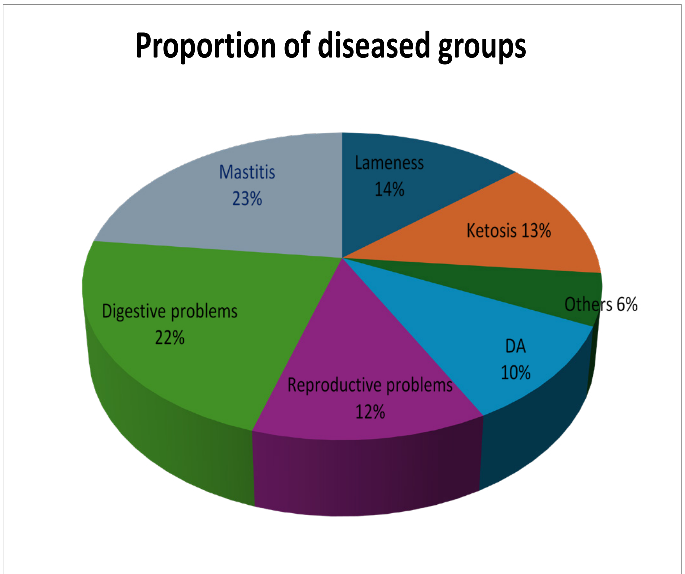

Figure 2: Proportion of diseased cow groups from alerts after clinical examinations and diagnosis.

The effect of breed and parity on rumination time and milk yield between seven days before alert and the alert day in mastitis, ketosis, and abomasal displacement

Rumination time of cows between seven days before the alert and the alert day were respectively 488.1 and 105.9 minutes/day in mastitis (P<0.01), 390.8 and 299.7 minutes/day in ketosis (P<0.01), and 373.3 and 157.0 minutes/day in abomasal displacement (P<0.01) (Table 6). However, comparing rumination time in breeds, the result indicated mastitis affected rumination time in both breed HF and HFxJS (P<0.01); ketosis and abomasal displacement only decreased rumination time in breed HF (P<0.05) and not affected in breed HFxJS (P>0.05) between seven days before the alert and the alert day. Moreover, cows suffered from abomasal displacement, and their milk yield would be decreased from 16.30 to 13.67 kg/day between seven days before the alert and the alert day (P<0.05). At the same time, mastitis and ketosis did not affect cow's milk yield between these times (P>0.05). Focus on the breed mastitis affected milk yield from 16.79 down to 13.47 kg/day in breed HFxJS (P<0.05), not decreasing the milk yield in breed HF (P>0.05). For both breeds HF and HFxJS, the results showed that ketosis and abomasal displacement did not significantly decrease milk yield (P>0.05) (Table 6). Breed HFxJS produced higher milk production, a hybrid between high milk yield HF and high-quality JS cows. So, HFxJS would be affected by diseases and high nutritional demands for milk production, including negative energy balance (Prendiville *et al.*, 2010). Therefore, HFxJS would decrease milk yield caused by diseases more than HF, especially in mastitis.

Regarding cows with mastitis, the reduction of rumination time between 7 days before the alert and the alert day was a considerable difference in parity 2, 3, 4, and 5 (P<0.01). In contrast to mastitis, the rumination time in ketosis decreased only in parity 1 (P<0.05); the differences of other parities were not seen as significant. In the case of cows with abomasal displacement, rumination time clearly showed a significant difference in parity 2, 3, and 4 (P<0.05) (Table 7). The milk yield decreased on the alert day for cows in parity 4 and 5 suffering from mastitis (P<0.01). Similarly, the milk yield was affected on the alert day for abomasal displacement in cows of parity 3 and 4 (P<0.05). While cows from ketosis reached increased milk production on the alert day, including parity 2, 3, and 4, and decreased milk production in parity 1 and 5, there were no significant differences (P>0.05) (Table 7).

Table 7: Rumination time before and on alert days for mastitis, ketosis, and abomasal displacement analyzed by parity.

Disease	Parity	N (cows)	Data	7 days before the alert	Alert day	P
Mastitis	1	8	Rumination time (x̄±SD, minute/day)	390.8 ± 138	274.4 ± 185.7	0.100
			Milk yield (x̄±SD, kg/day)	14 ± 10.95	13.94 ± 9.04	0.951
	2	17	Rumination time (x̄±SD, minute/day)	486.4 ± 76.4	357.3 ± 226.7	0.008
			Milk yield (x̄±SD, kg/day)	15.84 ± 13.67	12.95 ± 10.21	0.178
	3	19	Rumination time (x̄±SD, minute/day)	509.7 ± 95.3	297.8 ± 189.4	0.000
			Milk yield (x̄±SD, kg/day)	31.3 ± 10.7	15 ± 9.0	0.230
	4	21	Rumination time (x̄±SD, minute/day)	502 ± 85	288 ± 217.4	0.000
			Milk yield (x̄±SD, kg/day)	19.63 ± 12.02	12,67 ± 6.12	0.002
	5	29	Rumination time (x̄±SD, minute/day)	491.8 ± 122.3	403.1 ± 119	0.005
			Milk yield (x̄±SD, kg/day)	20.28 ± 12.64	15.46 ± 10.58	0.004
	Subtotal	94	Rumination time (x̄±SD, minute/day)	488.1 ± 336.9	105.9 ± 188.3	0.000
			Milk yield (x̄±SD, kg/day)	23.85 ± 47.78	14.16 ± 9.10	0.055
Ketosis	1	13	Rumination time (x̄±SD, minute/day)	335.4 ± 125.2	232.8 ± 132.7	0.031
			Milk yield (x̄±SD, kg/day)	16.35 ± 6.47	15.99 ± 4.31	0.792
	2	3	Rumination time (x̄±SD, minute/day)	433 ± 153	264 ± 205	0.499
			Milk yield (x̄±SD, kg/day)	17.70 ± 8.42	21.33 ± 0.79	0.496
	3	11	Rumination time (x̄±SD, minute/day)	398.7 ± 127.1	351.1 ± 160	0.288
			Milk yield (x̄±SD, kg/day)	17.66 ± 4.98	20.55 ± 3.25	0.134
	4	4	Rumination time (x̄±SD, minute/day)	490 ± 38	431 ±224	0.605
			Milk yield (x̄±SD, kg/day)	19.19 ± 5.27	22.74 ± 6.28	0.189
	5	3	Rumination time (x̄±SD, minute/day)	427 ± 66	261 ± 201	0.202
			Milk yield (x̄±SD, kg/day)	18.43 ± 5.7	17.14 ± 3.78	0.202
	Subtotal	34	Rumination time (x̄±SD, minute/day)	390.8 ± 123.0	299.7 ± 169.3	0.004
			Milk yield (x̄±SD, kg/day)	17.41 ± 5.7	18.83 ± 4.61	0,124
Abomasal displacement	1	8	Rumination time (x̄±SD, minute/day)	306.5 ± 105.2	202.3 ± 84.6	0,093
			Milk yield (x̄±SD, kg/day)	13.28 ± 5.1	12.22 ± 4.59	0,408
	2	4	Rumination time (x̄±SD, minute/day)	389.3 ± 148.7	134.0 ± 112.8	0,013
			Milk yield (x̄±SD, kg/day)	19.38 ± 11.27	15.78 ± 5.39	0.437
	3	8	Rumination time (x̄±SD, minute/day)	407.8 ± 149.8	136.9 ± 63.3	0.001
			Milk yield (x̄±SD, kg/day)	19.47 ± 9.56	14.25 ± 7.10	0.015
	4	3	Rumination time (x̄±SD, minute/day)	455.7 ± 121.2	207.7 ± 153.1	0.006
			Milk yield (x̄±SD, kg/day)	18.17 ± 11.52	17,67 ± 5.16	0.006
	5	2	Rumination time (x̄±SD, minute/day)	347 ± 196	26 ± 27	0.227
			Milk yield (x̄±SD, kg/day)	6.75 ± 1.34	6.95 ± 1.63	0.500
	Subtotal	25	Rumination time (x̄±SD, minute/day)	373.3 ± 134.9	157 ± 97.4	0.000
			Milk yield (x̄±SD, kg/day)	16.30 ± 8.79	13.67 ± 5.84	0.019

Table 8: Rumination time and milk yield on the alert day of mastitis, ketosis, and abomasal displacement in cows.

Monitoring index	Statistical parameter	Disease			P
		Mastitis	Ketosis	Abomasal displacement	
Ruminating time	N (Number of cows)	60	25	25	0.003
	x̄ (minutes/day)	292.2[a]	225.2[ab]	157.0[b]	
	SD (minutes/day)	200.4	128.0	97.4	
	CV (%)	68.58	56.85	62.06	
Milk production	N (Number of cows)	60	25	25	0.099
	x̄ (kg/day)	14.79	17.73	13.67	
	SD (minutes/day)	8.22	3.98	5.84	
	CV (%)	55.57	22.42	42.73	

Previous research identified that the parity factor (older cows) and high milk production might be affected more by mastitis (Elghafghuf *et al*., 2014). Higher parities also were seen as risk factors for abomasal displacement in dairy cows; cows of parity 3 had a higher threat than primiparous cows (Detilleux *et al*., 1997). The percentage of abomasal displacement was more elevated in cows during lactation 2 to 4 (Mokhber *et al*., 2013). As in previous studies, the explanation stemmed from aging and exposure to factors that caused abdominal muscle tone (Coppock, 1974). Additionally, milk production in cows with higher parity could be a risk of bomasal displacement (Fleischer *et al*., 2001). According to Kaufman *et al.* (2016), multiparous cows had a higher risk of ketosis than primiparous cows. In multiparous cows, higher milk yield in the previous lactation might increase disease percentage, and body condition declined more significantly during the transition period.

The results revealed that cows with mastitis exhibited the highest rumination time (292.2 minutes/day), followed by ketosis (225.2 minutes/day), and the shortest rumination time was observed in cows with abomasal displacement (157.0 minutes/day) ($P < 0.01$) (Table 8). The milk yield suffering from ketosis at 17.73 kg/day, lower in mastitis at 14.79 kg/day, and lowest in abomasal displacement cases at 13.67 kg/day) ($P > 0.05$). These results indicated that abomasal displacement significantly reduced rumination time and milk production, while ketosis moderately affected rumination time and mastitis notably decreased milk production.

CONCLUSIONS AND RECOMMENDATIONS

Monitoring systems based on rumination time and milk yield alerts were used to assist in the early detection of mastitis, ketosis, and abomasal displacement in dairy cow farms. The alert efficiency of the SCR system was 58.33%, including the highest alert rate in abomasal displacement (100%), relatively for ketosis (73.53%), and less for mastitis (63.83%). Rumination time before and on the alert day was decreased between the diseased and non-diseased cow groups. However, milk production only decreased in the diseased cow group. Besides, decreasing rumination time and milk yield were indicators of abomasal displacement, while reducing rumination time could be found in ketosis, and milk yield decreased in mastitis. Moreover, using SCR chips was essential in diagnosing and preventing diseases in dairy cows early.

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NOVELTY STATEMENT

SCR chips are implanted in cow's necks to monitor their rumination indexes and physical activities. Data will be analyzed by DataFlow™ II management software. SCR systems monitor rumination time and milk yield to identify health disorders of dairy cows. This study is the first comprehensive research to support early diagnosis of mastitis, ketosis, and abomasal displacement in dairy cow farms in Vietnam.

AUTHOR'S CONTRIBUTION

TTN, NQH, TKN, HTD, TPVAV: Conceptualization. TTN, NQH, TKN, HTD: Methodology. TTN, NQH, TPVAV: Formal analysis. TTN, NQH, TKN: Writing original draft preparation. TTN, TKN: Writing review and editing.

Conflict of interest

The authors have declared no conflict of interest.

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