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Individual Feed Intake of Transition Cows and Their Daily Activity Measures of Temperature, Eating, Rumination, Resting, and Activity Times

J. S. Stevenson
Kansas State University, jss@ksu.edu

C. S. Takiya
Kansas State University, takiya@k-state.edu

B. J. Bradford
Kansas State University, Manhattan, bbradfor@k-state.edu

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Abstract

Fifteen transition dairy cows bearing CowSensor® ear tags were monitored during 14 days before and after calving to assess temperature and behavior outcomes recorded by the sensors, in addition to actual individual dry matter and as-fed feed intake. The sensors—compared with reported visual observation studies—underestimated eating and resting times, but rumination time was estimated reasonably accurately. Expected changes in rumination (decreased acutely before calving and increased linearly to day 14) and general activity (increased acutely just before calving) were observed. More studies are warranted to determine how to use these activity monitors in detecting health disorders of cows that affect milk yield.

Keywords

behavior monitoring, sensor, validation

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Summary

Fifteen transition dairy cows bearing CowSensor® ear tags were monitored during 14 days before and after calving to assess temperature and behavior outcomes recorded by the sensors, in addition to actual individual dry matter and as-fed feed intake. The sensors—compared with reported visual observation studies—underestimated eating and resting times, but rumination time was estimated reasonably accurately. Expected changes in rumination (decreased acutely before calving and increased linearly to day 14) and general activity (increased acutely just before calving) were observed. More studies are warranted to determine how to use these activity monitors in detecting health disorders of cows that affect milk yield.

Introduction

Activity monitors can provide valuable management information about important behaviors of dairy cows that are correlated with economic traits associated with health, milk yield, and estrus detection. In the United States, more than a dozen different companies are marketing various types of activity monitors. All activity monitoring systems include three basic components: (1) sensor for each cow; (2) hardware receiver to collect the data from the sensors; and (3) computer software that outputs alerts and levels of activity. Sensors are presently in the form of either pastern-mounted pedometers, collar-mounted monitors, ear sensors, or rump-mounted transmitters. All sensors transfer data either using radio frequency or infrared technology to some configuration of a reader that transmits the data, usually in binary code, to a coordinator that translates and decodes the signal. The software is either located in an on-farm computer or a server that receives the information via web or cloud-based technology where the proprietary algorithms sort the information and determine which individual cows need attention. Website programs and apps, email alerts, text messages, and smartphone apps are available with most systems.

Measurements associated with rumination and its relationship to health was a comparatively new function in mid-2012. Some systems, such as the SCR system (Heatime®), track rumination with a tuned microphone that detects sounds of the bolus passing

up and down the esophagus and has been reported as a reliable source for detection of rumination (correlations = 0.94) when compared with visual observations of rumination minutes. The CowManager CowSensor® ear tags monitor ear and jaw movements and are used for detecting rumination, eating, resting, or active classifications by a three-dimensional accelerometer. The overall kappa values for the comparison of CowSensor® and visual observation was 0.78, with kappa values of 0.85, 0.77, 0.86, and 0.47 for rumination, eating, resting, and active, respectively. Similar to correlation coefficients, kappa values can range from −1 to +1, where zero represents the amount of agreement that can be expected from random chance, and 1 represents perfect agreement between the tested methods. Pearson correlation and concordance correlation coefficients between CowSensor® and visual observations for rumination, eating, resting, and active minutes per hour were 0.93, 0.88, 0.98, and 0.73 and 0.93, 0.75, 0.97, and 0.35, respectively. Peer-reviewed publications provide strong evidence that at least these two systems (SCR and CowSensor®) can be used to monitor ruminating and resting behavior of free stall-housed dairy cattle.

Our interest was in monitoring these important behaviors in transition cows, and examining their respective relationships during the transition period. Therefore, our objective was to describe the daily variations in temperature, measures of eating, rumination, and resting times, in addition to daily measures of activity in transition dairy cows.

Experimental Procedures

Close-up cows (n = 15) enrolled in the study between July 2017 and March 2018 were housed in an open-front, straw-bedded maternity barn equipped with automatic feed stations (Insentec RIC System, Hokofarm Group, Marknesse, the Netherlands) to monitor individual feed intake. After calving, cows were housed in individual tie stalls bedded with sawdust, fed individually, and milked thrice daily. Cows were fitted with CowSensor® ear tags (Agis CowManager, the Netherlands) during midgestation to monitor temperature, daily measures of eating, rumination, and resting times, in addition to daily measures of activity.

Data were captured hourly from the ear tags, stored in a cloud (remote server system), and downloaded daily into Excel spreadsheets. We averaged the hourly data to produce a daily mean of each activity captured by the ear tag, and measured actual feed intake in the same cows. This was a preliminary effort to examine these relationships to determine how they may be used in the future to predict and monitor important production and health traits of dairy cows.

Results and Discussion

To maximize cow comfort and health, it is generally believed that a daily time budget for a lactating dairy cow should consist of: (1) eating (3 to 5 hours); (2) lying and resting (12 to 14 hours); (3) rumination (7 to 10 hours); (4) social interactions (2 to 3 hours); (5) drinking (0.5 hours); and (6) no more than 2.5 to 3 hours in the holding pen and milking parlor. Note that the total hours per day exceed 24 hours because some activities occur concurrently such as lying and resting, and ruminating. In other words, cows excel as multitaskers.

The CowSensor® software sends estrus and health alerts based on a combination of behaviors and temperature detected by the ear tag sensors that are deciphered by proprietary algorithm software. For the 15 cows studied, health alerts were transmitted for three cows and estrus alerts for seven cows during the 48 hours surrounding the calving process. Only two cows had both alerts transmitted. The average 305-day mature-equivalent milk yield of the 15 cows studied was 32,631 lb and ranged from 26,512 to 38,165 lb.

Time and Intake Outcomes

Dry matter intake, as-fed feed intake, and eating and rumination times during the prepartum and postpartum periods are illustrated in Figure 1. Rumination decreased gradually as calving approached. It decreased acutely during the last 24 hours of gestation and bottomed out by 48 hours after calving. Thereafter, rumination increased linearly to day 14 after calving. On average, relative to before calving, rumination time increased ($P < 0.001$) by 10% during the post-calving period to 7.7 hours/day (Table 1).

Eating time, dry matter intake, and as-fed intake were relatively unchanged until 24 hours before calving when feed intake increased acutely after calving, whereas eating time decreased. On average, as-fed intake increased ($P < 0.001$) 41% and dry matter intake increased 24% after calving, whereas eating time decreased ($P < 0.001$) by 44% from prepartum to postpartum periods.

Resting and high activity (data not shown) times were relatively unchanged during the prepartum and postpartum periods (Figure 2). On average, measures of resting (no activity) did not differ between prepartum and postpartum periods (Table 1). In contrast, general activity increased acutely during 24 hours before calving and remained elevated for several days before slowly decreasing to day 14. On average, activity increased ($P < 0.001$) by 17% from the prepartum to postpartum period. Temperature increased gradually as calving approached and continued to increase only slightly to day 14. On average, temperature of cows did not differ from the prepartum to the postpartum period.

Correlations

Correlations among prepartum outcomes are shown in Table 2. Dry matter intake was correlated negatively with the estimated eating time and resting time, but correlated positively with rumination and temperature data collected via ear tags. Eating time and rumination were associated negatively with resting and activity. Rumination was positively correlated with temperature. As might be expected, resting was associated negatively with activity.

Correlations among postpartum outcomes are shown in Table 3. Dry matter intake was associated negatively with temperature, whereas eating time was correlated negatively with resting and activity. As with prepartum rumination times, rumination after calving was associated negatively with resting and activity. Postpartum activity was related positively with ear tag temperature.

General Discussion

Eating time was underestimated by the CowSensor® compared with other known visual observations of 3 to 5 hours per day. This underestimation in eating time is partly explained by the difference in energy density of diets fed before and after calving. Resting times of 7 to 8 hours per day were underestimated by the CowSensor® compared with visual observations of 12 to 14 hours per day. In contrast, rumination time was quite accurate and was in the range of 7 to 10 hours based on visual observations (Table 1). Rumination time is an important part of the system's ability to provide health alerts that also are tied to no activity or resting time and eating time.

Although the absolute hour measures of this system to estimate various behaviors are not consistent with accepted time budget results, their relative measures to identify outliers for health and estrus alerts are good. We have found in our general herd management that the CowSensor® does a great job of identifying cows with digestive issues hours before we visually identify these cows. The system showed that rumination time plummeted while inactive or resting status increased in these cows. Furthermore, rumination times also decrease acutely during 24 to 48 hours before cows come into estrus.

Conclusions

These preliminary results are promising for identifying behaviors that are associated with health and production while demonstrating their ability to measure behaviors typically observed visually in transition dairy cows.

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Table 1. Average prepartum (days -14 to -1; day 0 = calving) and postpartum (days 0 to 14) daily feed intake and daily activity monitor characteristics in 15 transition dairy cows

Item	Prepartum	Postpartum	*P*-value
Feed intake (lb/day)	41.8 ± 0.9	58.8 ± 0.8	<0.001
Dry matter intake (lb/day)	26.4 ± 0.4	32.7 ± 0.4	<0.001
Eating time (hours/day)	1.8 ± 0.04	1.0 ± 0.05	<0.001
Rumination (hours/day)	8.3 ± 0.1	8.6 ± 0.1	0.06
Resting (hours/day)	8.1 ± 0.1	8.1 ± 0.1	0.71
Activity (hours/day)	2.9 ± 0.04	3.4 ± 0.04	<0.001
Temperature[1] (°C)	27.8 ± 0.1	28.1 ± 0.1	0.13

[1]Ear tag measures the temperature around the ear, which is slightly warmer than the environmental temperature.

Table 2. Simple correlations among prepartum dry matter intake, cow temperature, and behavioral traits (days -14 to -1; day 0 = calving)

	Eating	Rumination	Resting	Activity	Temperature[1]
Dry matter intake (lb/day)	-0.22**	0.43**	-0.30**	0.20*	0.40**
Eating time (hours/day)		0.17*	-0.37**	-0.40**	-0.26**
Rumination (hours/day)			-0.73	-0.14	0.29**
Resting (hours/day)				-0.25**	-0.12
Activity (hours/day)					0.04

**$P < 0.01$.
*$P < 0.05$.
[1]Ear tag measures the temperature around the ear, which is slightly warmer than the environmental temperature.

Table 3. Simple correlations among postpartum dry matter intake, cow temperature, and behavioral traits (days 0 to 14 after calving)

	Eating	Rumination	Resting	Activity	Temperature[1]
Dry matter intake (lb/day)	-0.10	0.51**	-0.42**	-0.02	0.02
Eating time (hours/day)		0.03	-0.47**	-0.22**	0.05
Rumination (hours/day)			-0.60**	-0.42**	0.03
Resting (hours/day)				-0.11	-0.13
Activity (hours/day)					0.32**

**P < 0.01.
*P < 0.05.
[1]Ear tag measures the temperature around the ear that is slightly warmer than the environmental temperature.

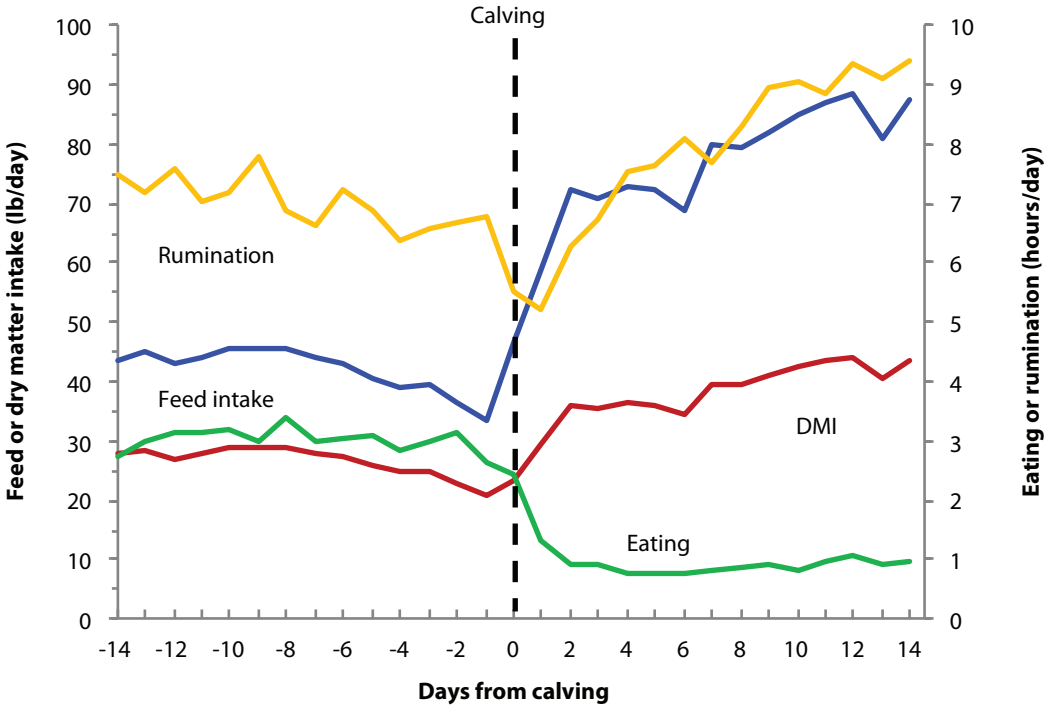

Figure 1. Daily dry matter intake (DMI; red), daily as-fed intake (blue), eating time (green), and rumination time (yellow) in 15 transition dairy cows during 14 days before and after calving.

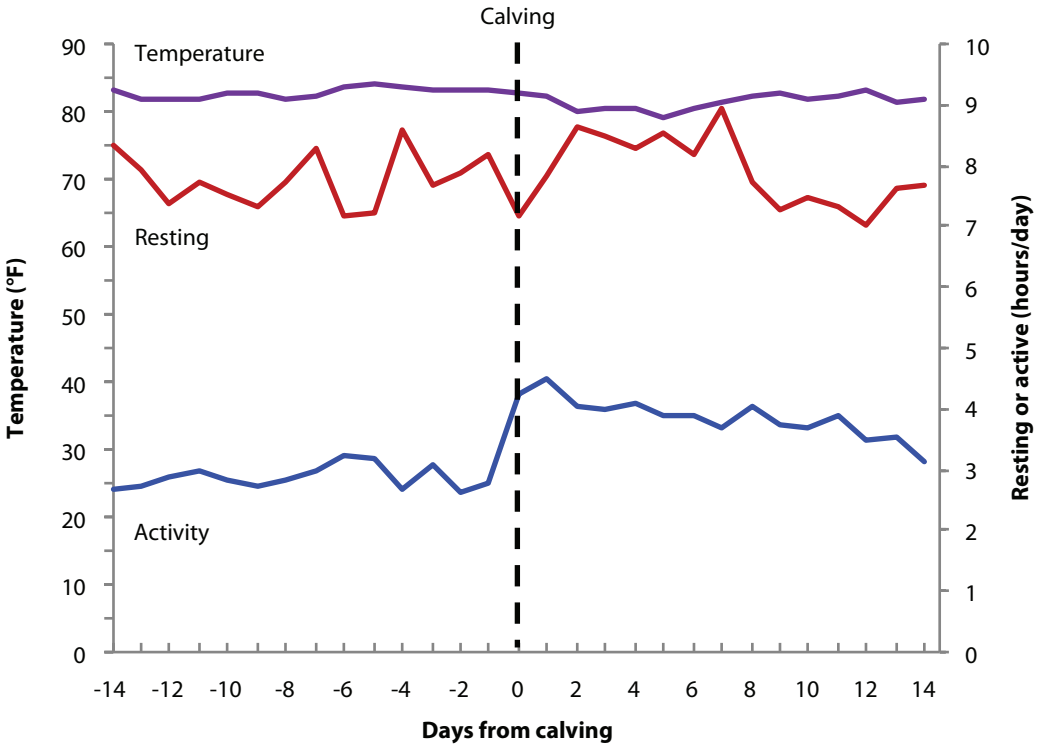

Figure 2. Daily ear tag temperature (purple), resting time (red), and activity time (blue) in 15 transition dairy cows during 14 days before and after calving.