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Technical note: Validation of a system for monitoring individual feeding behavior and individual feed intake in dairy cattle

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ABSTRACT

The objective of this study was to validate an electronic system for monitoring individual feeding behavior and feed intake (Intergado Ltd., Contagem, Minas Gerais, Brazil) in freestall-housed dairy cattle. No data have been published that validate either the behavioral measurement or the feed intake of this system. Feeding behavior data were recorded for 12 Holstein cows over 5 d using an Intergado system and time-lapse video. The cows were fitted with an ear tag containing a unique passive transponder and provided free access to 12 feed bins. The system documented the visit duration and feed intake by recording the animal identification number, bin number, initial and final times, and the difference between feed weight at start and end of each feed bin visit. These data were exported to Intergado web software and reports were generated. Electronic data on animal behavior were compared with video data collected during the same evaluation period. An external scale was used to manually measure and validate the electronic system's ability to monitor dairy cow feed intake for each feed bin visit. The feed intake was manually measured for 4-h time periods and compared with the sum of the feed intake recorded by the monitoring system for each cow visit during the same time period. Video and manual weight data were regressed on the electronic feeding behavior and feeding intake data to evaluate the precision of the monitoring system. The Intergado system presented high values for specificity (99.9%) and sensitivity (99.6%) for cow detection. The visit duration and feed intake per visit collected using the electronic monitoring system were similar to the video and manual weighing data, respectively. The difference between the feed intake measured manually and the sum of the electronically recorded feed intake was less than 250 g (25,635 ± 2,428 and 25,391 ± 2,428 g estimated using manual weighing and the electronic system, respectively). In conclusion, the Intergado system is a reasonable tool to monitor feeding behavior and feed intake for freestall-housed dairy cows.
Key words: dairy cattle, feeding behavior, validation

Technical Note

Feed intake and feeding behavior data on dairy and beef cattle has been traditionally collected using intensive research procedures, such as direct observation, time-lapse video recording, and manually measuring feed refusal. The methods are labor intensive, which limits their use over long time periods and for many animals. Moreover, most research has been performed under conditions that may not reflect the behavior of animals housed in groups, such as individual pens, tiestalls, or feed bins that limit animal access via barrier gates.

The increasing demand for a large database with feed intake as a phenotype feature for dairy and beef cattle-breeding programs, as well as the potential research on precision livestock farming, has motivated technological development of tools for monitoring behavior and feed intake data on individual cattle in large groups. The Intergado monitoring system (Intergado Ltd., Contagem, Minas Gerais, Brazil) determines individual feeding behavior and feed intake in cattle; however, no data have been published that validate this system for lactating dairy cattle. The objective of the current study was to validate the feeding behavior (bin-visit duration) and feed intake data collected from the Intergado system by comparison to time-lapse video recordings and manual feed intake measurements.

All animal care and handling procedures were approved by the Embrapa Dairy Cattle Animal Care and Use Committee (Juiz de Fora, Minas Gerais, Brazil). Twelve Holstein lactating cows were provided access to a sand-bedded freestall equipped with 12 electronic

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feed bins at the Embrapa Dairy Cattle research farm (Coronel Pacheco, Minas Gerais, Brazil). The cows were fed ad libitum a TMR consisting of 60% corn silage and 40% concentrate on a DM basis (DM: 47.8 ± 1.25%; CP: 16.8 ± 1.05% of DM; NDF: 45.8 ± 2.67% of DM; ADF: 34.5 ± 2.86% of DM; and NE_L: 1.6 Mcal/kg; analysis based on AOAC, 1990). The animals were fed daily at approximately 0600 and 1530 h and milked daily at approximately 0600 and 1530 h.

Each cow was fitted with an ear tag containing a unique passive transponder (FDX – ISO 11784/11785; Allflex, Joinville, SC, Brazil) in the right ear. The cows were also identified by symbols dyed on their heads and received a numbered ear tag in their left ear. Brackets designed to hold a video camera (Car Rear View Camera 1/4" OV136 CCD; RUI-LON, Guangzhou, China) were positioned at the midpoint between each set of 2 adjacent feed bins; the cameras were connected to a video recorder (DVR Stand Alone H.264; SPYA Express, São Paulo, Brazil). Fluorescent lamps (100 W) were located approximately 6 m above the bins to facilitate video recording at night. The clocks on the video recorder and Intergado monitoring system were synchronized.

The Intergado monitoring system (AF-1000 Master) includes a radio frequency identification antenna embedded in a rubberized mat that lines the neck bars and load cells to measure feed intake. After the cow steps on a mat located in front of the neck bars, the antenna is read upon activation of a mechanical switch with an integrated infrared presence sensor. The bin load cells included a 100-kg weighing capacity with ±25 g of accuracy. For each bin visit, the system recorded the animal number, bin number, initial and final times, and weight, and it calculated the duration and feed intake. These data were continuously recorded using a data collector via network cable and transferred to the Intergado web software via a general packet radio service. The system included a backup battery with up to 5 h of energy for when the main power fails. The feed bins were 0.80 m wide, 1.00 m long, and 0.40 m deep.

The cows were continuously monitored for 5 consecutive days to evaluate the feed bin visit duration. The time-lapse video recordings were assessed by 3 trained observers. The animals were scored as present or absent at the feed bins when their head passed over the neck bars.

The system's ability to monitor feed intake per visit, on an as-fed basis, was validated for each feed bin by removing and weighing the feed using an external scale (model 2096 DO/IV, Toledo, São Paulo, Brazil) at the beginning and end of 153 cow visits. For each single bunk visit, the TMR was manually removed and weighed; the feed bin was refilled thereafter. The feed intake was estimated using the monitoring system and then compared with the manually estimated feed intake (initial weight minus final weight, which were determined using an external scale).

To discern cumulative errors, beginning immediately after a fresh feed delivery, the total feed intake was manually recorded over a 4-h period for 3 different days using an external scale and subtracting the weight of any remaining orts in the bin from the amount of feed provided. This value was then compared with the sum of the feed intake recorded by the monitoring system for each cow visit during the same period.

Feeding behavior and feed intake data generated by the Intergado monitoring system (dependent variable) were regressed onto those from direct observation (independent variable), and the 95% confidence limit of PROC REG CLI option of SAS 9.4. (SAS Institute Inc., Cary, NC) was used for testing slope equals one and intercept equals zero. The difference between the electronically registered and manually measured cumulative feed intake, as well as feeding duration over a 4-h period, were analyzed using the SAS 9.4 MIXED procedure (SAS Institute Inc.), fitting method (observed or recorded) as fixed effects and the feed bin as a random effect.

The manually measured average feed intake per visit (1,998 ± 138 g) was similar to the monitoring system measurements (1,979 ± 138 g; Table 1). Bach et al. (2004) compared a monitoring system with manual weights using an external scale before and after a total of 26 feed bin visits and described a difference of 52 g per visit ($P = 0.99$). Chapinal et al. (2007) also analyzed the relationship between feed intake per visit using electronic and direct observations based on the bin's digital display and did not measure difference between the methods.

The regression slope for the manually weighed feed intake per bin visit on feed intake per bin visit estimated using the monitoring system did not differ significantly ($P < 0.05$) from 1, which indicates similarity between the methods (Table 2). The monitoring system accurately measured the feed consumption. A 15-g systematic error was detected, but this error was lower than the load cell accuracy and can be considered small.

The total feed that disappeared from each feed bin over a 4-h period was compared with electronic measurements over the same period and differed by 244 g (25,635 ± 2,428 and 25,391 ± 2,428 g estimated through manual weighing and using the electronic system, respectively). During the observation period, the electronic system detected 2,756 cow visits to the feed

Table 1. Least squares means ± SEM and maximum as well as minimum values for feeding intake (g) and duration (s), which were estimated through electronic recordings, manual weighing, and video observations

		Direct observation			Electronic observation		
Variable	n	LSM	Minimum	Maximum	LSM	Minimum	Maximum
Feeding intake[1]							
Per visit[2]	153	1,998 ± 138	10	7,630	1,979 ± 138	0	7,650
Per period[3]	12	25,635 ± 2,428	7,560	37,790	25,391 ± 2,428	7,375	37,525
Feeding duration							
Per visit[4]	2,753	170 ± 2	1	3,666	174 ± 2	0	3,666
Per period[5]	60	10,119 ± 403	3,600	17,440	10,128 ± 403	3,702	17,400

[1]Fresh matter basis.

[2]Intake per visit to feed bin.

[3]Intake per 4-h period.

[4]Time spent feeding per visit to feed bin.

[5]Total time spent feeding in 4-h period.

bins, whereas 2,764 visits were detected using video recording. In 10 events, a cow was present and detected by video recording but not by the monitoring system, which indicates 99.64% sensitivity. In 2 events, a cow was considered absent from the feed bin using video recording, but the monitoring system considered the animal present; thus, the monitoring system specificity is 99.93%.

The electronic system defined the start and end of a visit based on animal detection using the presence sensor. In contrast, using video recording, the visit duration was assessed based on the time that the animal's head crossed the neck bar. On 2 occasions, the animals moved their head away from the feed bin, but they were detected by the presence sensor. Therefore, the animal was considered absent from the feed bin based on the video analysis, but the monitoring system indicated that the animal was present.

DeVries et al. (2003) reported a sensitivity and specificity of 87.7 and 99.2%, respectively, for an electronic feeding behavior system that monitored a cow's presence at a feeding area. Bach et al. (2004) detected a sensitivity and specificity of 99.6 and 98.8%, respectively, for an electronic system that monitored feeding behavior and individual feed intake. Mendes et al. (2011) determined a sensitivity and specificity of 86.4 and 99.6%, respectively, for an electronic feeding behavior-monitoring system.

The time spent in the feed bin, which was determined using the monitoring system and video recording, were similar (Table 1). The regression slope for visit length, which was estimated using the monitoring system and video recording, did not differ ($P < 0.05$) from 1 (Table 2). The systematic error did not differ from zero. The regression coefficient was higher than the coefficient calculated for bunk visit event duration by Mendes et al. (2011; $R^2 = 0.81$).

In one event, the monitoring system recorded a feed bin visit duration much longer than the duration recorded by video (Figure 1). This difference was due to a malfunction in the feed bin presence sensor, which indicated an uninterrupted feed bin visit by the cow

Table 2. Regression equations and confidence limits for feeding intake (g) and duration (s) using the electronic observations, manual weighing, and video observations

	Estimated		95% Confidence limits				
Variable	Intercept	Slope	Intercept		Slope		R^2
Feeding intake[1]							
Per visit[2]	−15.997	0.998	−25.967	−6.026	0.995	1.002	0.99
Per period[3]	137.634	1.004	−291.454	566.723	0.988	1.020	0.99
Feeding duration							
Per visit[4]	0.314	0.999	−0.480	1.108	0.997	1.002	0.99
Per period[5]	58.191	0.993	−90.766	207.149	0.979	1.007	0.99

[1]Fresh matter basis.

[2]Intake per visit to feed bin.

[3]Intake per 4-h period.

[4]Time spent feeding per visit to feed bin.

[5]Total time spent feeding in 4-h period.

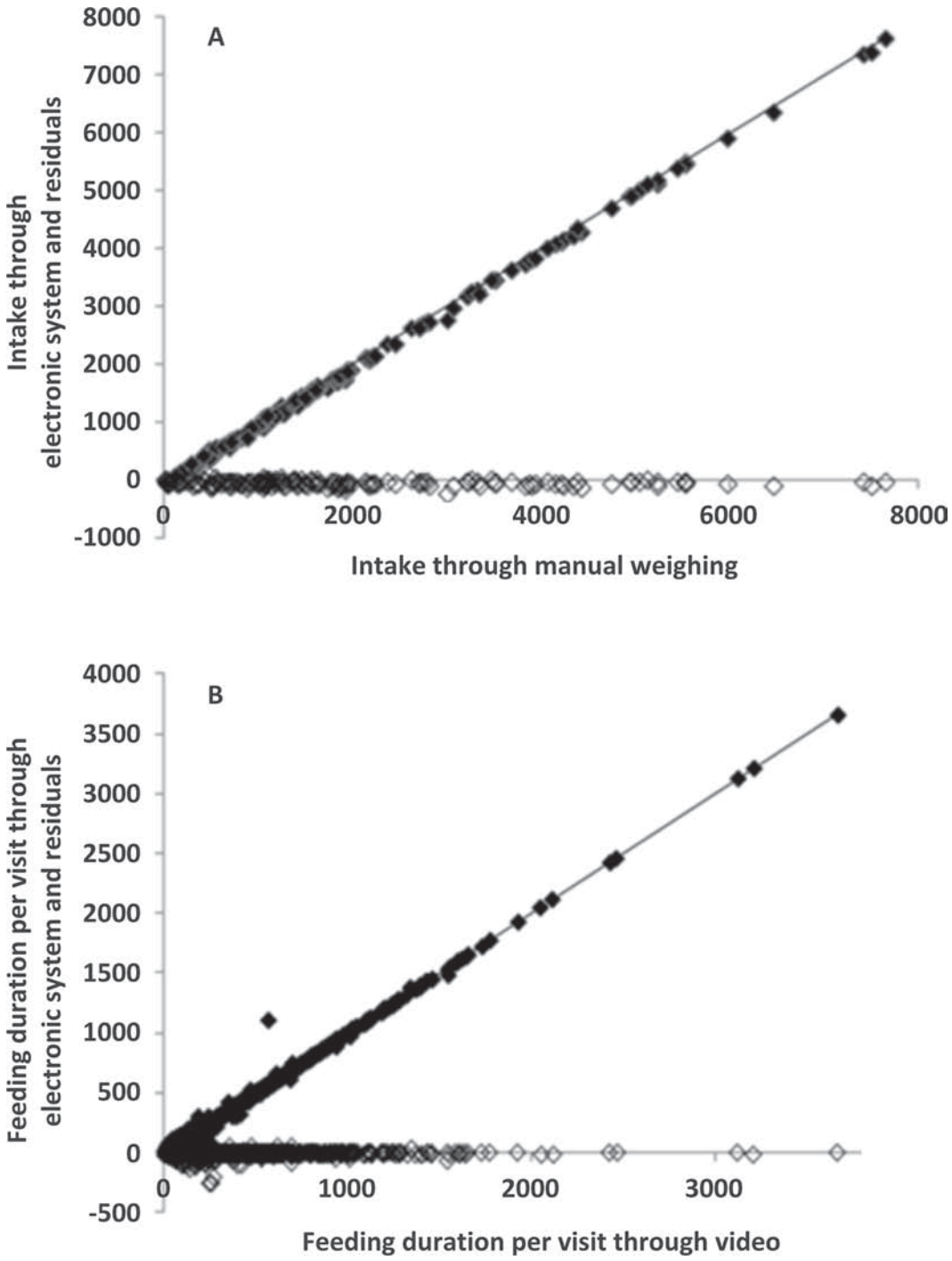

Figure 1. Recorded (solid symbols) feed intake (A; g) and duration (B; s) per bin visit through the electronic system or through manual weighing and video observations. Open symbols represents residuals.

until another animal arrived at this feed bin. The presence sensor must be improved to avoid further error due to mechanical failure of the mat switcher.

In conclusion, the Intergado system provides a reasonable monitoring system for feeding behavior and feed intake by freestall-housed dairy cows.

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