Accuracy of the FeedPhone device for recording eating and rumination times in dairy cows

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Abstract

Several commercially available devices automatically record feeding behaviour of dairy cows on farm, but independent validation studies are often not available. The objective of this study was to determine the accuracy of the FeedPhone® device, developed in France by Medria, to record eating and rumination activities of dairy cows. The FeedPhone is based on a tri-axial accelerometer placed on a collar, data being radio-transferred and processed automatically. The main activity (eating, rumination, or rest) is recorded every 5 min. Validation was performed on 7 lactating dairy cows fed on maize silage and concentrates for a total of 89 full day records. The actual times were determined by a reference method, by recording continuously the weight of the trough and the jaw movements at the minute scale. At the day level, the mean prediction error was 11.5% for eating time and 11.1% for rumination times, with low mean and slope biases (error mainly random). Eating and rumination activities are clearly distinguishable. This precision enables the detection of between-day variations of both eating or rumination times of 20, 10, and 5%, at cow level, small-herd level (4-7 cows) and larger herd level (>20 cows), respectively. This accuracy makes the FeedPhone valuable for studying relative variations of both eating and rumination times of dairy cows fed on total mixed ration.

Keywords: cattle, behaviour, methodology, accelerometer, accuracy

Introduction

Ruminant feeding behaviour has been recorded for a long time for scientific purposes to better understand and predict animal-feed relationships. More recently, advanced technologies allow continuous recording of on-farm dairy cow feeding behaviour and oestrus activity while also detecting health or nutritional events such as acidosis periods, either at cow or herd levels. This involves, however, accurate recording of eating and/or rumination activities. Several devices have been developed recently, most of them being based on biaxial or tri-axial accelerometers (Nielsen, 2013; Umemura, 2013). The objective of this work was to determine the precision and accuracy of the FeedPhone®, a new device for automatically recording eating and rumination times and the daily pattern of these events, which can be used on-farm for dairy herd management but also in ruminant research studies.

Materials and methods

Seven mid-lactating Holstein dairy cows were fed *ad libitum* during several weeks on a total mixed ration which comprised 59% maize silage, 39% concentrates and 2% minerals. After several days of adaptation, feeding behaviour was recorded continuously during 20 days from December 2013 to January 2014 by two independent methods: (1) the INRA reference method for measuring actual eating and rumination times, and (2) the Feedphone device developed by Medria for measuring predicted eating and rumination times. The INRA method consists of combining data from automatic weighing troughs and from bite meters. The bite meter is made up of a small balloon filled with foam rubber placed on the lower jaw and connected by a silicone tube to a pressure recorder (Baumont *et al.*, 2004). Feeding activity is interpreted each minute and classified as eating, rumination, or resting. The FeedPhone uses the Axel® sensor placed on a properly fitted collar on the cow's neck. The sensor consists of a micro-electromechanical tri-axial accelerometer that measures and continuously analyses the changes of inclination and lateral and vertical

accelerations. A set of nine statistical data is recorded every 5 min, automatically transmitted to the Box Medria by a radio link and thereafter to the data centre by a GPRS radio or internet connection. In the data centre, the processing algorithms on servers convert the raw data into new standardised data. The algorithms determine the main activity (here also classified as rumination, eating, or rest) for every 5 min period. They also determine if the animal is standing or lying down, and distinguish between eating at the barn or at grazing.

The accuracy of the FeedPhone in estimating eating and rumination time was investigated by calculating the mean prediction error (MPE, in min or in proportion to actual mean value), and the proportional contribution of mean bias, line bias and random variation to the mean-squared prediction error (MSPE) (Bibby and Toutenburg, 1977). Accuracy was investigated per day or per hour, by summing activities recorded at 5 min periods (FeedPhone) or at every 1 min period (INRA). Short unclear behaviour periods from the INRA reference system were not considered.

Results and discussion

The validation study involved a total of 89 complete cow × day recordings, for a total of 2,212 h of validation. At the day scale, the mean prediction error was 11.5% (42 min d^{-1}) for eating time and 11.1% (59 min d^{-1}) for rumination time, when the FeedPhone is compared to the INRA reference method used as the 'gold standard'. As no 'gold standard' is perfect (the INRA method is also an indirect method), it may be hypothesized that true accuracy should probably be greater. For eating time, part of the error comes from an under-estimation of low actual eating times (Figure 1), leading to a small overall under-estimation of eating time (-18 min d^{-1}, 18% of MSPE; Table 1). For rumination time, error is mainly random (97% of MSPE) with low mean and slope biases but greater dispersion (Figure 1). At the hour scale, mean prediction error is of 39% (5.7 min h^{-1}) for eating time and 35% (7.5 min h^{-1}) for rumination

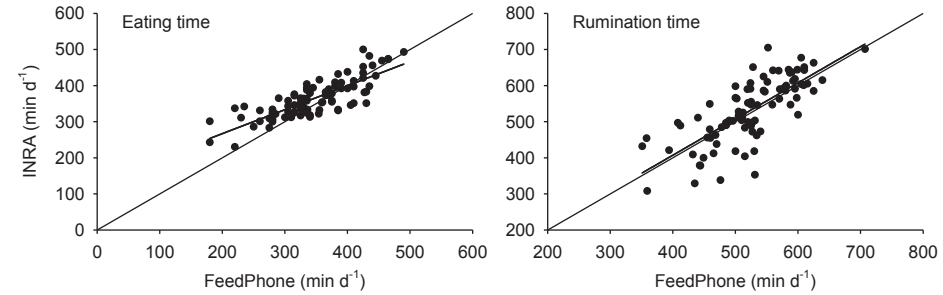

Figure 1. Daily eating and rumination times estimated by the FeedPhone or by INRA reference method on 7 cows during 20 days (total of 89 recordings).

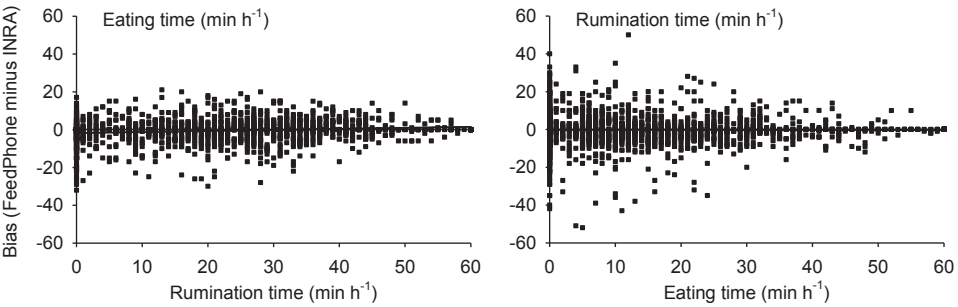

Figure 2. Relationship, for each of the 2,212 h of validation, between the bias (FeedPhone minus INRA) in eating or rumination time and the other feeding activity time (rumination for eating, and eating for rumination).

Table 1. Accuracy of the FeedPhone to record eating and rumination time in lactating dairy cows fed on a total mixed ration based on maize silage (89 d and 2,212 h of validation).

Scale	Activity	INRA	FeedPhone	MPE[1]		MSPE[1]		
		min	min	min	% mean	% mean	% slope	% random
Day	eating	364	346	41.8	11.5	18	27	55
	rumination	531	523	58.8	11.1	2	0	98
Hour	eating	14.6	13.9	5.7	39.2	2	1	97
	rumination	21.4	21.1	7.5	35.2	0	3	97

[1] MPE = mean prediction error; MPSE = mean square prediction error.

time, with no mean or slope biases, 97% of MSPE being random (Table 1). At the hour scale, there was no significant relationship between eating time bias and rumination time, nor between rumination time bias and eating time (Figure 2). It is noticeable that when a cow is engaged in a feeding activity (>40 min h^{-1}), there are only very small biases in the other feeding activity (Figure 2). This clearly shows the ability of the processing algorithms to classify feeding activities into either eating or rumination activity.

From mean prediction error observed at the day scale, it can be extrapolated that at individual cow scale, at small herd size scale like in this study (4-7 cows), or at larger herd size scale (>20 cows), the accuracy of the FeedPhone seems sufficient to detect between-day variations of eating and rumination times of about 20, 10 and 5%, respectively. Additional validation studies are needed to determine accuracy of the FeedPhone on cows fed on pasture silage, hay and/or under grazing.

Conclusions

At the day level, the FeedPhone is able to record automatically the eating and rumination time of dairy cows fed on a maize silage-based diet with a precision of 89 to 90% for both activities. Data analysis at the hour scale shows that algorithms are specific enough for clearly identifying the eating and rumination activities. This overall accuracy is good enough to make the FeedPhone a valuable tool for studying relative variations of both eating and rumination times of dairy cows.

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