Test of a sensor to estimate grazing and ruminating time in dairy cow behaviour at pasture

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Abstract

Use of automated tools in farms is raising worldwide. Diverse applications are available. One of them aims to optimize grazing through monitoring of rumination and ingestion times. The objective of this study was to evaluate the accuracy of the sensor developed by Medria to estimate grazing (G) and rumination (Ru) on pasture. This sensor including a tri-axial accelerometer provides data every 5 minutes. The trial lasted 12 days on 12 grazing cows in the CTA (Belgium), representing 380 h of observations. The data registered by the Medria device (M) were confronted to visual observation (VO). The datasets were compared using Fleiss-κ estimating the concordance of 5-min observations and linear regression analysis was used to estimate the Pearson correlation coefficients (rp) and relative prediction error (RPE). Moderate for G (κ =0.502) and poor agreement for Ru (κ =0.175) were observed. Linear relationship between VO and M was highlighted with rp: 0.793; *P*<0.001 for G and rp =0.32; *P*<0.05 for Ru. The relative error prediction was 0.16 and 0.44 for G and Ru respectively. With regards to these results, reliable data about grazing are provided on a daily basis. The reliability of rumination data is poor.

Keywords: smart farming, sensors, rumination, grazing, accelerometer

Introduction

Increasing size of farms and the lack in manpower have contributed to the development of smart farming which allows automation of several tasks and facilitate animal management by providing information on e.g. the behaviour of the animals, and even generates alerts if the recorded behaviour does not correspond to that registered on previous days. Evaluation of grazing and rumination times of grazing dairy cows is of key interest for managing grazing. Indeed lack of information on intake of grazed grass has been highlighted as a reason for stopping grazing (Lessire et al., 2019). Sensors using different technologies are commercialised: nosebands recording electrical resistance, micro-phones recording ingestion and rumination and bi or tri-axial accelerometers (Ambriz-Vilchis et al., 2015; Delagarde and Lamberton, 2015; Pereira et al., 2018; Werner et al., 2018). The objective of this study is to estimate the accuracy of a tri-axial accelerometer commercialised by the French company Medria (Saint-Lo – France) for estimation of grazing and rumination times in grazing cows. This accelerometer is mounted on a collar that determines the major activity on a time interval of 5 minutes. Eight activities are discriminated. The data provided by the sensors are compared with visual observations that are considered as reference standard.

Materials and methods

The study was carried out at the Centre of Agronomic Technologies (5.31°E, 50.507°N) located in Strée (Modave) in Belgium. The trial was conducted from 14 to 21 June and from 6 to 13 July 2021, for a total of 380 h of observations. Twelve Prim’Holstein cows (milk yield - MY: 25.3 ± 6.1 kg; lactation number – LN: 2.9 ± 1.9, including 4 primiparous; days in milk- DIM: 173 ± 39 days) selected out of 2 groups grazing permanent grassland paddocks. The paddocks of 1.96 and 2.02 ha respectively were managed by strip grazing granting access to fresh grass. A complementation of 4 kg concentrate (CP: 16%; 870 VEM) was supplied at barn.

Sensors were mounted on collars adjusted on the neck of the cows. Four cows were observed per day during 8 hours divided into 4 observation periods (6h10-8h10, 9h-12h, 13h-15h and 16h-17h). The most predominant behaviour on a 5-minutes period was noted. The Medria device continuously records behaviours, but only indicates a "single majority activity" over a 5 min interval. Visual observations collected over the entire trial period were collected by the same trained operator. A trial period involving several observers validated the operator's recognition of the behaviour according to the definitions of Medria: grazing is "a low head position, close to the ground and necessarily efficient frontal and slightly lateral movements with straight segments." It is also stated that "the animal may ingest a little with its head up". Thus the behaviour recorded as grazing includes searching, prehension and mastication. For rumination, the Medria device defines it as "a metronome movement, from a high position of the head". The reference method is based on the following definition: "with circular movements of the head and jaw, the cow continuously regurgitates and swallows a bolus". Every behaviour lasting more than 30 seconds was recorded, then we choose to select the most predominant activity i.e. the one with the longest cumulative duration over this period. Other activities such as heat-related behaviour, resting, ruminating, eating or over-activity are also reported by Medria, so that 8 behaviours were discriminated, i.e standing (S), lying (L), lying rumination (LR), standing rumination (SR), ingestion at barn (BI) or on pastures (G), over-activity (OA - which compares current activity to that recorded on previous days to indicate the likelihood of heat) and other (O). A total of 380h of observation was reached. In this study, we will only discuss the results obtained for G and Ru summing the data of LR and SR.

Statistical analysis using SAS software and R includes the comparison of each collected data (visual observations - VO vs sensor observations -M) on a 5 minutes period using the proc freq procedure to determine the freq of agreement between both methods, then the concordance coefficient of Fleiss (κ) was calculated using R (package irr). In a second step, the duration of each behaviour was calculated considering it lasted during 5 minutes so that the duration over the daily observation time (8h) was estimated for each of them for VO and M. Linear regression (proc reg and proc corr; SAS) was used to assess the agreement between the 2 methods. The mean root prediction error and relative prediction error were calculated following the method described by Delagarde et al. (2015). Only results regarding G, and rumination (Ru) are shown.

Results

The Figure 1 shows the frequencies (%) of the different behaviours recorded by M. The M agreed with VO for G in 64.0%, 30.4% for LR and 12.1% for SR. In 28.4% of the behaviours identified by VO as LR, M indicated L while SR was frequently confused with LR (36%). Thus, we decided to merge LR and SR in Ru. The κ-coefficient estimated at 0.502 for G and 0.175 for Ru indicated moderate and poor agreement for G and Ru respectively.

The total duration of G and Ru over a daily observation period i.e 8h were 192 ± 71 min (range: 70 –395 min), 112 ± 40 min (range: 35 –205 min) for VO vs 168 ± 62 min (range: 55 –335 min), 141 ± 52 (range: 40 –270 min) for M. The duration of G and Ru estimated by M were linearly correlated with VO. The Pearson coefficient was 0.793; *P*<0.001 for G and 0.32; *P*<0.05 for Ru. The results are summarized in Table 1.

Table 1. Results of the linear regression linking M and VO observations.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | n obs | mean VO (min) | mean Medria(min) | intercept | slope | SE | R² | MSPE | RPE |
| Grazing | 47 | 191.7 | 167.3 | 35.11 | 0.69 | 0.08 | 0.63 | 29.9 | 0.16 |
| Rumination | 47 | 112.3 | 140.6 | 87.75 | 0.47 | 0.18 | 0.13 | 49.5 | 0.44 |

Abbreviations: VO: visual observation; SE: standard error of the slope; MSPE: mean square prediction error; RPE: relative prediction error.

Discussion and conclusion

The advantages of Medria sensors are numerous: they are cheap, robust, their battery is long-lasting and they provide other valuable information i.e about the probability of heat. Alerts about unusual behaviour duration are sent by different media, so that they are appreciated by the farmers. In consideration with the acceptable value of κ-coefficient and the strength of the correlation coefficient between VO and M observations, grazing time could be considered as accurately measured by the Medria sensors. Lower duration values than observed are measured but the RPE remained low (12%). Whether based on the κ -coeficient or the RPE estimate, rumination behaviour was not accurately discriminated and duration time provided by Medria sensors was not reliable. Therefore, we can conclude that in our study condition the data provided by Medria sensor could be used to assess the G behaviour but not the rumination.

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Figure 1. Comparison of the occurrence of the different behaviours recorded by M with the behaviour G, LR and SR identified by VO. Abbreviations: G: grazing. LR and SR: lying and standing rumination