Scientific Report: Short Term Scientific Mission (STSM)

Acoustic monitoring of ingestive and rumination behavior in barn-housed dairy cows and the amalgamation with the RumiWatch system.

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Background

Monitoring of ingestive and rumination behavior performed by ruminants is important for the early detection of health problems, for the timely detection of oestrus, detection of impaired welfare, as well as for the estimation of intake. Depending on the conditions, direct observation is difficult to realize and always time consuming. Therefore, in the recent years different systems have been developed to record and analyze behavioral characteristics automatically. Two of these are the acoustic monitoring system (**AMS**) (Ungar and Rutter, 2006) and the RumiWatch System (**RWS**) (Ruuska et al., 2016), which allow automatic recording and subsequently differentiation of jaw movements performed by ruminants. The AMS, consisting of a contact microphone, fixed with a halter on the head of the ruminant, allows measuring of the grinding sound generated by the ruminants while eating and ruminating. The RWS measures are based on a pressure sensor and a triaxial accelerometer embedded in a halter. The pressure sensor provides records of jaw movements performed while eating or ruminating and the triaxial accelerometer records the acceleration of head movements in the three axes.

Objectives of the STSM

As the applicant mainly performed investigations with the RWS and showed no experience with the AMS, the objectives of the current STSM were:

- Learn the utilization of the AMS by use in a short investigation.

- Try to combine the AMS and the RWS to measure ingestive and rumination behaviors in barn-housed dairy cows simultaneously.

- To detect the accuracy of the AMS / RWS combination by aid of visual observation.

Materials and methods

During the STSM an investigation was performed at the research farm (31° 59' 18.3" N, 34° 49' 26.2" E) of the Volcani Center, consisting of one feeding treatment and one measuring period. The period lasted 14 d, consisting of 6 d of adaptation for the cow to the measuring system and 8 d of data collection. Four multiparous Holstein dairy cows were used for the experiment. These cows showed at the beginning of the experiment an average BW of 691 (SD 33.9) kg, were 197 (SD 60.8) days in milk, were in the 3.5 (SD 1.7) lactation and produced 43.3 (SD 11.2) kg of milk/d. The cows were kept in an open pen and received a TMR ad libitum, offered in weighing troughs (in-house development, The Volcani Center, Israel) (**Picture 1**). The TMR consisted of 20.2% crushed corn, 14.8% gluten, 14.2% whole plant corn silage, 10.8% whole plant wheat silage, 9% oat straw, 8.9% dried distiller grain, 7.1% oil cake, 4.8% wheat, 3.3% barley, 2.1% treated cotton seed, 1.4% Ca salt, 1% protected fat, 1% bicarbonate, 0.6% mother liquor, 0.4% lime stone and 0.3% urea.

Behavioral characteristics were concurrently recorded with the AMS (in-house development, The Volcani Center, Israel) and the RWS (Itin and Hoch GmbH, Liestal, Switzerland). To enable the concurrent measuring, the AMS (noncommercial available prototype) was configured as an add-on to the RumiWatch halter (**RWH**) (**Picture 2**). Therefore, the AMS contact microphone (CM-01B, Germany, MEAS Deutschland GmbH, Dortmund, Germany) was placed into a rubber tube over the nose bridge behind the pressure sensor of the RWS, and the recording device (Sansa Clip^{+}, SanDisk, Milpitas, California) of the AMS was taped to the right jaw belt of the RWH. Thereby the AMS enables a detection of the grinding sound generated while eating and ruminating. At the same time, the RWS enabled the detection of pressure changes caused by jaw movements by aid of a pressure sensor and three-dimensional movements of the head by aid of a triaxial accelerometer. The

AMS collected data with a frequency of 24 kHz and the RWS with a frequency of 10 Hz. Setup and handling of the AMS / RWS halter was similar to that of a standard cow halter. To ensure the best detection of the jaw movements by both systems, between the belt around the nose and the lower jaw 3 to 5 cm of movement space to the nose bridge was left and the front part of the belt was located between 11 and 16 cm behind the nasal tip.

To validate the results measured and evaluated by the two systems, direct observations were performed. During an observation sequence, one cow was continuously observed for 10 min. The cumulative duration of observation for each cow lasted 240 min. The same observer performed all validation sequences; this resulted in 96 sequences (1 experimental period x 24 sequences x 4 cows). To detect potential diurnal differences in the quality of the raw data recorded with the combined system, the observations were conducted throughout the day from 0730 h to 1920 h.

The RWS enable a detection and evaluation of number of boli, chews per boli, mastication chews with the head up, mastication chews with the head down, prehension bites, rumination chews, drinking gulps respectively time spent in ruminating, masticating, eating, and drinking. The AMS contains no triaxial accelerometer, therefore a differentiation between mastication chews with the head up and with the head down is not possible, besides this the aforementioned parameters are also detectable. Therefore the observed behavioral characteristics during visual observations were: number of boli, chews per boli, mastication chews with the head up, mastication chews with the head down, prehension bites, rumination chews, drinking gulps respectively time spent in ruminating, masticating, and eating and drinking.

Data analysis

For the foreseen scientific paper, total number and duration of the visually observed behavioral characteristics should be compared with simultaneously recorded RWH data

processed with Converter 0.7.3.31 (Itin & Hoch GmbH, Converter 0.7.3.31) and the aural evaluated AMS data. Therefore, the mean absolute percentage error between the visual observation and the RWS or the AMS respectively should be calculated, for each behavioral characteristic, and compared to each other.

Description of the preliminary findings

As the data evaluation is not finished yet, only preliminary insights of this STSM can be presented. It could be noted that a combination of both systems is possible, as the AMS could be attached to the RWH. Furthermore the evaluation of the raw data showed, that the RWH had problems with the time shift between the Swiss and Israeli time zone, as at the beginning of the investigation no accurate time setting was possible. Besides this, comparing to former investigations with grazing dairy cows the RWS revealed difficulties in differentiating between mastication chews and prehension bites for stall-fed cows. This is illustrated by the large deviations, detected for mastication chews and prehension bites compared to visual observation (**Table 1**). Furthermore, no accurate detection of the drinking behavior is possible by the RWS. Nonetheless, the RWH enables an accurate evaluation for the number of eating chews, rumination chews, bolus and chews per bolus and the time spent in eating and ruminating. In contrast to the RWS, the AMS recordings were not analyzed automatically and therefore raw data had to be evaluated manually by aural evaluation, which is very time-consuming. Another weak point of the AMS is the short recording time of about 12h. Actually, continuous recordings of behavioral characteristics over one day are not possible yet. The evaluation of the AMS recordings, the solving of the aforementioned problems and to perform an experiment in grazing cattle might be a good base for a further collaboration.

Summary statement

In addition to the opportunity to perform an investigation with stall-fed dairy cows in Israel, this STSM enabled me to get in contact with another worldwide operating institute and witness it in operation. Furthermore, I got an insight how acoustic signals could be used for detection of behavioral characteristics, what additionally deepen my understanding of the system and helps me to understand in more detail the complex and challenging task of detecting and evaluating behavioral characteristics in ruminants.

Future collaboration with the host institution

This STSM brought together Agroscope, Institute for Livestock Sciences the University of Bonn and the Volcani Center, Institute of Plant Sciences, and might be the base for further collaborations between the aforementioned parties.

Foreseen publications resulting from this STSM

Following the data evaluation, one scientific paper would be written and submit to the journal “Computers and Electronics in Agriculture”.

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References

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Ungar, E. D. and S. M. Rutter. 2006. Classifying cattle jaw movements: Comparing IGER Behaviour Recorder and acoustic techniques. Applied Animal Behaviour Science 98:11-27.

Table 1. Mean absolute deviation (%) of the RWS compared to the 10 min continuous visual observation

Behavior	Deviation (%)
Ingestive behavior mean absolute deviation percent	
Eating time	18.7
Eating chews	10.6
Prehension bites	48.3
Mastication & prehension bites head down	38.8
Mastication & prehension time head down	32.3
Mastication chews head up	34.5
Mastication time head up	39.3
Ruminating behavior mean absolute deviation percent	
Rumination time	3.64
Rumination chews	4.29
Bolus count	10.3
Chews per bolus	13.2
Drinking behavior mean absolute deviation percent	
Drink time	199
Drink gulps	153

Picture 1: Housing of the experimental cows with weighing trough.

Picture 2: Holstein cow wearing the AWS / RWS combination.

[1] AMS recording device encased into a metal box and fixed to the RWS by tape
[2] AMS contact microphone encased into a rubber tube mounted over the nose bridge and connected to the AMS recording device.
[3] RumiWatch halter consisting the halter a triaxial accelerometer (encased into the black plastic box) and a pressure sensor (located in the belt over the nose bridge)