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Validation of a sensor-based automatic measurement system for monitoring chewing activity in horses

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ABSTRACT

The aim of this study was to determine the feasibility of using a jaw movement measuring system developed for cattle, the "RumiWatchSystem", on horses. The system records the chewing activity and consists of a noseband pressure sensor, integrated into a halter, and a software package. In order to investigate the accuracy of the system, 10 horses (5 mares, 5 stallions) were equipped with the device. Additionally, they were observed visually as a reference method, while feeding three different feeds (hay, haylage and concentrate). To ensure similar conditions, the horses were stabled individually and fed twice daily with roughage and twice or three times with concentrate. The results of the visual observation were compared to the automatic measurement as an evaluation of the accuracy of the automatic measurement system.

The overall agreement of the observed and automatically measured data within all feedstuffs was 93%. The agreement of feeding roughage was even higher with 95%. However, for concentrate the visual observations and automatic measurements agreed only in 91.4%. The decreased agreement compared to the roughage is due to the high sensitivity of the automated system. Horses tend to display a high amount of lip movements towards the end of the concentrate intake. This is different compared to cattle behaviour and their feeding regime. However, the system was not specifically adapted to horses so far and can be optimized in order to improve accuracy. Consequently, the system has a high potential to become a reliable tool for research and practical use.

1. Introduction

The chewing activity of horses can be a suitable parameter for health and welfare assessment as the prevalent housing and feeding conditions often leave horses unsatisfied. Evolutionary, horses adapted over a long period of time to their ecological niche (Janis, 1976). They used to live as grazers in steps with poor vegetation. Therefore, they are adjusted to a low energy and high fibre diet. The feed intake behaviour is defined by a long intake time of 12–16 h (Zeitler-Feicht, 2008; McGreevy, 2004) and travelling long distances of up to 28 km a day (Hampson et al., 2010). Because of the natural food resource, the gastric system is well adapted to small feeding bouts and a consistent filling of the stomach. With the help of microbial fermentation in the large caecum, it is possible to split high fibre feed (Frape, 2010). In modern housing systems, compared to the natural behaviour, horses are often fed roughage restrictive (twice daily) with an additional feeding of grains. This leads to a high amount of starch over a small period of time and can cause illness of the gastrointestinal system like gastric ulcerations (Hymøller et al., 2012). Even in pleasure horses the prevalence of gastric ulcer is 40–60% (Niedźwiedź et al., 2013). Additionally, horses are mostly individually stabled and there is often little or no possibility of social contact to other horses. In Northern Germany, 10% of stabled horses do not even have the possibility to observe their environment (Petersen et al., 2005). This deviation of natural behaviour may lead to abnormalities or stereotypies (Cooper and Albentosa 2005) and even to serious health problems. To evaluate and monitor the feed intake behaviour of a horse, it would be very valuable to measure the chewing activity automatically. The "RumiWatchSystem" could provide us with an assessment tool for different feeding regimes and husbandry systems.

There are still a number of unanswered questions, e.g. why such a high number of stomach ulcers occur in horses. Analyzing the chewing behaviour linked to different feeding regimes would provide us with valuable information and might lead us to the solution how to reduce stomach ulcers. Another possibility to use

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the system is to apply it in horse dentistry.

The jaw movements are an empiric and valid parameter to determine the chewing behaviour and was already subject of investigations (Bonin et al., 2007, Vervuert et al., 2013). However, there was no appropriate system to measure the chewing activity automatically until 2012, when the "RumiWatchSystem" became commercially available for cattle. Therefore, our aim was to test the equipment on horses in order to find out, if this would be an appropriate tool to improve horse management.

2. Material and methods

2.1. The automatic measurement system

The "RumiWatchSystem" (Itin+Hoch GmbH, Liestal, Switzerland) consists of a noseband pressure sensor with acceleration sensor, data logger with on-board analysis, and a software package including the "RumiWatchConverter Version 0.7.2.0" and the "RumiWatchManager Version 0.9.6". The sensor system was integrated into a commercially available horse halter as already described in Nydegger et al. (2010), (Fig. 1). An oil-filled silicon tube with integrated pressure sensor in the noseband transmitted a signal to the data logger with a 10 Hz frequency, which was mounted in a plastic box at one end of the noseband. The signal was formed by a pressure difference inside the silicon tube due to jaw movements of a horse. These raw data were saved as binary data on an SD memory card, which was also located in the plastic box. Additionally, raw data were saved as a csv-file, labelled according to the four categories: eating, ruminating, drinking or other activities. This classification was done by an algorithm, originally developed for cattle.

The power supply was provided by a 3.6 V battery, which lasts for 3 years under laboratory conditions due to a low energy operating system. It was mounted in a second plastic box on the other side of the noseband. The raw data transfer was made via a USB plug-in connection. Additionally, 24 h-summaries divided in 1 h-summaries were transmitted wireless via an ANT-standard-antenna to the "RumiWatchManager" software.

The automatic quantification of the chewing activity was determined by pressure peaks. Every peak above the threshold of 28 mbar was counted as a chew. The absolute values could not be taken into account because the pressure inside the silicon tube was not standardized. That means precisely, that not the height of a peak determined the chewing activity but the frequency of peaks. In this study, there was no differentiation between chews and bites. Additional information about the system can be found in Nydegger et al. (2011), Zehner (2012) and Zehner et al. (2012).

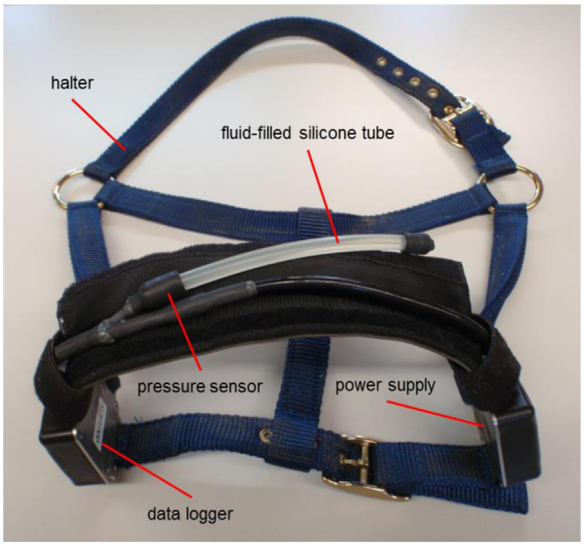

Fig. 1. Specifics of the automated measurement system ("RumiWatch"), integrated in a commercially available horse halter.

2.2. Animals, housing, feeding management

In this study, ten horses (5 stallions, 5 mares) were used. Two breeds were included in the trials, eight "Freiberger" and two "Swiss Warmblood". They aged 8 to 17 years and weighed on average 601 ± 38 kg. All horses were stabled individually and were bedded on straw with daily access to paddocks. Mares were not used for exercise, but stallions were schooled under saddle or driven 2-4 days a week. Before the study commenced, all horses were checked by veterinarians of the "Institut suisse de médecine equine" (ISME-Swiss Institute of Equine Medicine, Avenches, Switzerland) regarding their body condition and dental health. There were no specific findings, which would differ from a normal health status.

The feeding management was adjusted to the experimental design. All horses were fed twice daily with roughage (hay or haylage). Concentrate was fed twice a day to mares and three times a day to stallions. The sensory analysis of feed revealed a good quality for both groups, stallions and mares. However, the hay of the stallion group appeared to have a lower amount of structure than the hay of the mares group. The haylage for both groups was of equal quality and appearance. The concentrate was a mixture of pellets, bruised barley, corn flakes, sunflower seeds and linseeds.

2.3. Experimental design

The horses were observed visually – as a reference method – while feeding three different types of feed (hay, haylage and concentrate). Therefore, all five horses of each group (mares/stallions) were equipped with a noseband pressure sensor, integrated in a leather halter. The visual observations were recorded with a tablet device. A modified Microsoft Excel sheet with a user interface enabled the observer to record each jaw movement with a time stamp and behavioural category (Zehner 2012). These categories needed to be determined manually in advance. In our case we chose the categories "feed intake roughage", "feed intake concentrate", "drinking" and "other activities".

The study was divided into four trial periods (Table 1); mares hay, mares haylage, stallions hay, stallions haylage. Within each trial period, the horses were observed visually for 10 min in the morning and 10 min in the evening while feeding either hay or haylage over duration of three days. There was an adaptation period with no observation of at least three days in between the different trial periods. Additionally, all horses were observed while eating concentrate for 5 min, except of the mares in Trial period 2. As Trial period 1 showed that the concentrate intake of the mares lasted often less long than the observation period, it was decided to adapt the observation period to the actual intake time (3–9 min) in Trial period 2.

2.4. Data evaluation

The comparison of both systems (observational and automated) was based on the amount of chews per minute. The evaluation software "RumiWatchConverter" was used for the analysis of the automatically recorded data. The converter was able to summarize the recorded data minute by minute regarding the amount of chews. The observational measurements were analyzed by manually counting the detected chews.