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Automatic registration of grazing behaviour in dairy cows using 3D activity loggers

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ABSTRACT

Automated systems for monitoring behaviour of cows within dairy production are increasing and developments in technology provide new opportunities in this area. This study aimed to validate the use of a 3D activity logger (HOBO® Pendant G Data Logger), that registers the cow's head positions during grazing, to distinguish grazing behaviour from non-grazing behaviour.

20 lactating dairy cows of the breed Swedish Red were included in the trial. All cows were observed for 30 min each day either in the morning or afternoon. The behavioural observations were conducted by two trained observers during 5 h a day for ten days, 2.5 h in the morning (9:30–12:00 am) and 2.5 h in the evening (06:00–08:30 pm). Each cow had a logger attached to the right bottom side of the halter and the logging interval was set to 5 s, which means that the head inclination was measured every fifth second. Furthermore an IceTag3D™ logger was attached to the right hind leg of each cow in order to evaluate if this information together with the information from the 3D activity sensor could increase the precision of the prediction. The DISCRIM procedure in SAS 9.12 was used to find the optimal value of a linear discrimination between grazing and non-grazing registrations and the 3D activity sensor was validated with 5 s, 5 min and 10 min logging intervals between observations points against the visual observation of grazing behaviour. The 5 and 10 min logging point was taken from the 5 s logging point occurring with 5 and 10 min interval.

The sensitivity (recognizing grazing behaviour as grazing) of the 3D activity sensor without or with the information from the IceTag logger with 10 min interval was below 60% and thus not useful in determining grazing behaviour. However, the sensitivity of the 3D activity sensor alone was 83.6 and 85.5% for 5 s and 5 min respectively. The specificity (recognizing non-grazing behaviour as non-grazing) of the 3D activity sensor was 79.9 and 82.1% and the precision (proportion of calculated gracing behaviour that is real grazing behaviour) was 74.6 and 77.6% for 5 s and 5 min respectively. When the information from the IceTag3D™ was added to the data the sensitivity remained the same while the specificity increased to 90.2 and 90.5% and the precision was 85.8 and 86.8% for 5 s and 5 min respectively.

It is concluded that a 3D activity logger is a useful tool for a continuous automatic registration of grazing behaviour in dairy cows.

1. Introduction

To manually observe grazing behaviour of cows in order to obtain information regarding grazing time is time consuming and not an option in modern dairy husbandry or

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for large scale grazing experiments for research purposes. Estimates based on automatic recordings would therefore be an advantage (Nielsen et al., 2010) but the technology would need to have a high precision in discriminating grazing and non-grazing behaviour. Additional, it should also be cost efficient to be beneficial to the dairy farmer.

Automated systems for monitoring the behaviour of cows within dairy production have become increasingly important for management routines and for monitoring health and welfare on individual basis and relatively common. Development in technology gives new opportunities for monitoring of behaviour (de Passillé et al., 2010). Today there are a number of activity metres that can differentiate between lying, standing and walking behaviour (Pastell et al., 2009; de Passillé et al., 2010; Ledgerwood et al., 2010). There is also some equipment available to identify grazing behaviour such as leg switch movement, jaw movement (Umemura et al., 2009) and biting and chewing sounds (Laca and Wallis De Vries, 2000), with additional information regarding bite mass and intake rate (Rutter et al., 1997) but most of these techniques are expensive and labour intensive and it is therefore of interest to examine the potential of a sensor that is widely available on the global market.

The aim of this study was to validate the capacity of a 3D activity measuring device (HOBO® G Pendant Data Logger, USA) to differentiate a cow's grazing behaviour at pasture from non-grazing behaviour. The device registers the cow's head positions. In this study registrations from the 3D activity sensor were compared with visual behavioural observations and the value of combining the sensor data with data from another activity sensor (IceTag3D™) that registers leg movement and standing/lying behaviour was explored. The 3D activity sensor has previously been used for measuring grazing behaviour in goats (Moreau et al., 2009) and for measuring general activity in dairy cows (Ito et al., 2009) and sows (Ringgenberg et al., 2010).

2. Materials and methods

The study was performed at the Swedish University of Agricultural Sciences research centre Kungsängen in Uppsala, during ten days at the beginning of June 2010. The study was approved by the Uppsala Local Committee of Ethics in Animal Testing (Ref. no. C74-10) in agreement with the Swedish animal welfare regulations.

2.1. Animals

A total of 20 lactating dairy cows of the breed Swedish Red from the experimental herd of Kungsängen participated in the trial. Mean body weight at the beginning of the period was 622 kg (range 550–742 kg). Four cows were primiparous and 16 were multiparous with lactation number varying from 1 to 5 (mean = 3.0) and a mean of 130.8 days in milk (range 33–335 DIM). Average milk yield of the 20 cows throughout the study was 33.7 l/day (range 19.7–48.9 l/day).

The 20 cows were allocated into two groups with ten cows in each balancing the groups for lactation stage and lactation number due to the experimental setting of another study. A field (2.5 ha) was divided into four equally sized paddocks (ABCD). The paddocks were separated with electric fences. Group 1 changed between paddock A and B, and group 2 between C and D to always ensure a satisfactory pasture. Both groups were managed under standard summer grazing conditions with 24 h grazing. The cows were only away from the pasture for milking twice a day between 06:00 and 08:00 am, and 03:30 and 06:00 pm when they were milked with standard milking machines in a tied up barn about 10 min of walking from the paddocks. At milking the cows received a small feed allocation of silage (3–4 kg DM) and concentrate according to their level of milk production.

Table 1
Ethogram with descriptions of the registered behaviours.

Behaviour	Description of behaviour
Grazing while standing	Standing with muzzle ≤ 15 cm from the ground
Grazing while walking	Walking with muzzle ≤ 15 cm from the ground
Non-grazing	The cow is not performing either of the above mentioned grazing behaviours

2.2. Behavioural observations

The behaviour was recorded using personal digital assistants (PSION Workabout, Psion Teklogix, Canada) and observations were made during 5 h a day for ten days, 2.5 h in the morning (9:30–12:00 am) and 2.5 h in the evening (≈6:00–08:30 pm). The observations were performed by two observers. On a particular day all 20 cows were observed. Each cow was observed for 30 min per day and thus for a total of 5 h during the whole observation period. The behaviours which were registered using continuous sampling are presented in Table 1. The observers were standing in the unused paddock in full view of all cows. Each cow was marked on the side with an individual number (1–20), in a luminescent colour.

2.3. Technical equipment

The cows were fitted with two types of activity sensors one day prior to the start of recordings, one on the halter and the other on one back leg.

2.3.1. Grazing sensors

Each cow had a sensor (HOBO® Pendant G Acceleration Data Logger, USA) attached to the halter, in order to record the head positions during the registered behaviours. The sensor was positioned such that the *x*-axis was parallel to the jawline, pointing towards the muzzle, and the *y*-axis was perpendicular to the jawline, in the direction towards the eye (Fig. 1). The unit was waterproof and measured 58 mm × 33 mm × 23 mm and weighed 18 g. Plastic cable ties were used to fix the sensor to the halter (Fig. 1).

The HOBO® sensor is a three-channel sensor, but number of channels is selectable and for this study changes in inclination measurements in two axes (two dimensions) were chosen, *x* and *y*, since the exclusion of the third channel would not impact the quality of the grazing activity