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Using sound technology to automatically detect the short-term feeding behaviours of broiler chickens

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ABSTRACT

This paper describes a novel monitoring system to accurately detect the short-term feeding behaviours (meal size, meal duration, meals per day and feeding rate) of broiler chickens at group level by a real-time sound processing technology. In this research, the pecking sounds of 10 male, 39 days old, broiler chickens were recorded by a microphone that was attached to the feeder. Simultaneously, the appearances of broilers around feeder were recorded by a camera that was positioned at the top of the feeding pen. At the same time, a weighing system was used to automatically record feed uptake of broilers as a reference method. Moreover, an existing algorithm was used to detect the pecking sounds of 10 broiler chickens while the birds were all eating together. The feeding behaviours of broiler chickens were obtained by pecking sound analysis. The results of the algorithm were compared to reference feeding behaviours through weighing system measurements and video observations. The relationship between feeding behaviours obtained by algorithm and feeding behaviours recorded by a weighing scale and video camera was investigated and a strong positive correlation was found between these methods. Furthermore, the linear regression tests which were performed which were performed resulted in the following coefficients of determination R^2 = 0.965 for meal size, 0.938 for meal duration, 0.896 for the number of meals per day and 0.888 for feeding rate. Additionally, the estimated accuracy of the method showed that, 90% of meal size, 95% of meal duration, 94% of the number of meals per day and 89% of feeding rate were correctly monitored using sound analysis. The results suggest that this automated continuous measurement system has the potential to be used as a tool to monitor the short-term feeding behaviours of broiler chickens at group level. The most important advantage of this system is that the measurements can be made continuously throughout the life span of a flock, in a fully automated, completely non-invasive and non-intrusive way. It is proposed to test this system in commercial conditions due to its low costs and in order to evaluate its applicability under these conditions. Future researches should be focused on sound technology to assess the health and welfare of broilers by automatically and continuously monitoring the feeding behaviours.

1. Introduction

Solutions to measure the feed intake and feeding behaviours of chickens have previously been presented in the literature (Hulsey and Martin, 1991; Yo et al., 1997; Savory and Mann, 1999; Gates and Xin, 2001; Puma et al., 2001; Persyn et al., 2004). More specifically, a system that utilizes a network of top-loading balances digitally interfaced to a Macintosh computer was developed by Hulsey and Martin (1991). Two forms of data which allow the evaluation of the animal's biting and/or licking behaviour in addition to cumulative food intake and meal patterns were simultaneously collected by their system. Another technique was developed by Yo et al. (1997) for evaluation of the feed pecking in young chickens. Three different techniques were compared to define the feed pecking of chickens. They concluded that videotaping with slow-motion focal sampling (V) offers potential development for the study of food intake behaviour of chickens. In 2001, an instrumentation system which had a precision electronic balance was developed by Puma et al. (2001) to study the dynamic feeding and drinking behaviour of individual birds. They concluded that the system can characterize dynamic poultry feeding and drinking behaviour. Another study quantified feeding behaviour of W-36 White Leghorn laying hens (77–80 weeks old) as influenced by the management practice of beak trimming using weighing scales (Persyn et al., 2004). It was

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concluded that the results demonstrate the adaptability of the hen to beak trimming in terms of achieving its daily feed/energy intake by varying its ingestion kinetics or pattern.

However, this assessment methodology (manual labelling of video observations and assessment of weighing scale data) is time-consuming, hence costly, tedious and prone to errors, even with modern commercially available research systems which compile the statistics semi-autonomously (Gates and Xin, 2001). Therefore, there is an increasing need for systems which can further automate collection of event-based behavioural responses (Gates et al., 1995; Gates and Xin, 2001; Xin et al., 1993).

In another study, Gates and Xin (2008) developed algorithms for determining individual bird feeding statistics and stereotyped pecking behaviour from time-series recordings of feed weight and compared them to video observations. In another study, related to turkey breeding, a structured query language (SQL) database management system was developed to record and manage the dynamic feed intake and body weight gain data of individual birds (Xuyong et al., 2011). The system also offers a powerful research tool for studying poultry feeding behaviour under group housing conditions (Xuyong et al., 2011).

This is the case in broiler houses where a reliable identification of feed intake was important to assess health and welfare of broiler chickens and to detect short-term feeding behaviours such as feeding rate, number of meals per day, meal duration and meal size. Meals are considered to be a more biologically relevant unit for studying short-term feeding behaviour than feeding events such as visits to feeders (Tolkamp et al., 2000). Meal size and duration are thought to be controlled by hunger and satiety mechanisms that affect the start and end of meals.

Except for the study of Aydin et al. (2014), in scientific literature up to date, the same methodology was applied to define the feed intake and feeding behaviours of poultry, based on weighing scale data. As different from the previous studies in literature, the detection of the pecking sound of an individual chicken was investigated by Aydin et al. (2014), using a developed sound algorithm to define the feed intake of broiler chickens. In their study, the pecking sound of each individual chicken was recorded by a contacted microphone under the feeder to calculate the feed intake of broilers. The results showed that 93% of the pecking sounds were correctly identified and 90% of feed intake was correctly monitored using sound analysis. Furthermore, the feed intake curves of algorithm and weighing scale were also quite similar and parallel to each other (Aydin et al., 2014).

It was concluded by Aydin et al. (2015) that the proposed system can be used for a real-time monitoring the feeding behaviours of broiler chickens, because the correlation between the feed intakes measured by algorithm and feed intakes recorded by a weighing scale was very high. One of the advantages of this fully automated continuous monitoring system is that the dynamic changes in feeding behaviour over time can be easily monitored in addition to the feed intake. So, the feeding behaviours (meal size, meal duration and the number of meals per day) of broiler chickens can easily, automatically and continuously be monitored and analysed by researchers with this system in a real time (Aydin et al., 2015) to answer the following questions, under laboratory conditions. When do the birds start to eat? What is the duration of a meal? What is the quantity of a meal? How many times do they eat in a day?

As different from previous studies in the literature (Hulsey and Martin, 1991; Yo et al., 1997; Savory and Mann, 1999; Gates and Xin, 2001, 2008; Puma et al., 2001; Persyn et al., 2004), this research which is the following study of Aydin et al. (2015) represents the first attempt to automatically and continuously measure the short-term feeding behaviours of broiler chickens in a non-invasive way by sound technology. The first objective of this research was to non-invasively detect the short-term feeding behaviours of broiler chickens by sound analyses. The second objective of this study was to provide a novel tool for further research to assess the health and welfare of broiler chickens in relation to feeding behaviours. The third objective of this research was to examine whether the system for further research and possible commercial use which was developed by Aydin et al. (2015) can indeed be utilised to assess the short-term feeding behaviours, health and welfare of a group of broiler chickens.

2. Materials and methods

2.1. Experimental setup

The pecking sounds of 10 broiler chickens were continuously recorded for seven days. In total 10 birds were used in the experiments. Each day, 24 repetitions were performed with the same 10 broilers at group level and each experiment lasted for 60 min. In total, 168 experiments were performed with the same 10 broiler chickens during this study. All birds were placed in a pen ($100 \times 100 \times 50$ cm) with a density of 10 birds per feeder and the pecking sounds were recorded while the birds were all eating together. In the experiment, a commercial feeder was used and an electrets microphone (Monacor ECM 3005) was attached to the bottom of this feeder (Fig. 1). The microphone was connected to PC via preamplifier (Monacor SPR-6). All recordings were sampled at 44.1 kHz with 16 bit resolution.

All sounds such as pecking, singing and environmental sounds like door and ventilation system sounds were continuously recorded. Simultaneously, video recordings were performed with a top view camera for the validation of sound data with manual labelling. An USB webcam (Logitech Webcam Pro 9000) with 3.7 mm Carl Zeiss® lens was positioned to the top of the cage at 200 cm distance (Fig. 1). Light was kept on at 90 lx during video recordings. Images were captured with a resolution of 640 horizontal by 480 vertical pixels at a sample rate of 15 frames per second. As a reference measurement, the feed uptake of chickens was automatically and continuously recorded (sampling frequency of 10 Hz) by a weighing system. The data obtained by this weighing system was automatically transferred to the PC via RS-232 cable. The feeder was placed on a precision balance (KERN PCB-8000, with weighing range 8000 g and accuracy 0.01 g) (Aydin et al., 2015).

The sound data were analysed by a pecking detection algorithm developed by Aydin et al. (2014) in MATLAB® (Mathworks) and the feeding behaviours of broilers was calculated based on pecking sound information. The weighing data and video observations were used to validate the proposed algorithm. The pecking sound results of the algorithm were compared to reference feeding characteristics through weighing system measurements and video recordings to assess the short-term feeding behaviours of broiler chickens.

2.2. Birds and housing

The experiments were performed with 10 male, 39 days old, Ross 308 broilers. The birds were transported to the laboratory in two hours from a local farm (Provincial Center for Applied Poultry Research, Geel, Belgium). Birds were kept on floor pens $1 \times 1 \times 1$ m on wood shavings. 300 μm particle size feed and water were freely available for all birds. Two days adaptation period were given to the birds in order to recover from the stress of transport and acclimatise to their new environment (Aydin et al., 2015).