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An innovative approach to predict the growth in intensive poultry farming

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ABSTRACT

Chicken weight provides information about growth and feed conversion of the flock in order to identify deviations from the expected homogeneous growth trend of the birds. This paper proposes a novel method to automatically measure the growth rate of broiler chickens by sound analysis.

Through the application of process engineering, Precision Livestock Farming (PLF) can combine audio and video information into on-line automated tools that can be used to control, monitor and model the behaviour, health and production of animals and their biological response.

The aim of this study was to record and analyse broiler vocalisations under normal farm conditions, to identify the relation between animal sounds and their weight. Recordings were made at regular intervals, during the entire life of birds, in order to evaluate the variation of frequency and bandwidth of the sounds emitted by the animals.

Two experimental trials were carried out in an indoor reared broiler farm; the audio recording procedures lasted for 38 days. The recordings were made, in an automated, non-invasive and non-intrusive way and without disturbing the animals in to the broiler house. Once a week, 50 birds were selected at random and their weight recorded in order to follow the growth trend in the birds.

Sound recordings were manually analysed and labelled using the Adobe® Audition™ CS6 software.

Analysing the sounds recorded, it was possible to find a significant correlation ($P < 0.001$) between the frequencies of the vocalisations recorded and the weight of the broilers.

The results explained how the frequency of the sounds emitted by the animals was inversely proportional to the age and to the weight of the broilers; the more they grow, the lower the frequency of the sounds emitted by the animals.

This preliminary study, conducted in an indoor reared broiler farm, shows how this method based on the identification of specific frequencies of the sounds, linked to the age and to the weight of the birds, might be used as an early warning method/system to evaluate the health and welfare status of the animals at farm level. This is the basis for a further development of an automated growth monitoring tool.

1. Introduction

The demand for meat is rapidly growing all over the world (Tullo et al., 2013) and poultry is one of the cheapest sources of animal protein. Currently, more than 50 billion chickens are produced every year by specialised industries according to FAOSTAT (2015).

Broilers are the fastest-growing farmed species and their performance is influenced by adequate environmental conditions such as environmental temperature, relative humidity, air and litter quality, and ventilation speed. Thank to the progress in farming technologies, broiler chickens now mature at a higer rate than in the past, have higher feed conversion efficiency, a reduced slaughter age and a higher final weight (Aerts et al., 2003; Rauw et al., 1998).

Chicken weight provides information about the growth and the feed conversion efficiency of the flock. Nowadays, the weight of the birds is automatically collected by a single solid "step on scale" placed on the floor of the house. The high numbers of animals inside the flock and the insufficient funds of scales make impossible to collect the weight of all flock. Manually measure the weight

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of a significant number of animals requires manpower and deprives the farmer of useful time. Due to this, it might be useful to automatically collect simultaneously information about the growth trend of all the birds inside the flock to identify deviations from the expected homogeneous growth trend of the birds (Fontana et al., 2014; Mollah et al., 2010), having also details about the health and welfare status of the animals.

Since the animal health strongly depends on good welfare, during the last years many progresses have been made in developing new indices/indexes and procedures to assess animal's health and welfare status (Fontana et al., 2015). Nevertheless, these monitoring procedures are time consuming and require trained manpower (Aydin et al., 2014). For this reason, one possible way to make animal welfare assessment easier and faster could be the application of audio and video data analysis (Ferrari et al., 2013; Tefera, 2012; Tullo et al., 2013).

Image analysis, in particular, was successfully used to estimate the body weight of the animals (Mollah et al., 2010), while audio analysis have been widely used to better identify specific behaviours and vocalisation patterns in different animals' species (Chan et al., 2011; Vandermeulen et al., 2013).

Animals use vocalisation to express different inner states provoked either by internal or external events, and also to reveal some of their behavioural needs (Aydin et al., 2014; Vandermeulen et al., 2015). For instance, chicken broiler vocalisations have been studied (Feltenstein et al., 2002; Marx et al., 2001; Montevecchi et al., 1973) to better understand the vocal pattern of this species in relation to environmental temperatures and stress situations (e.g. high/low temperatures). Moreover, information technologies have been used to monitor feed intake, body weight and growth trend (Aydin et al., 2014).

The non-invasive nature of the audio and video equipment allows its use in long term monitoring of animals, without disturbing them (Aydin et al., 2013; Fontana et al., 2015).

The combination of audio and video information into automated tools could be used in early warning systems to detect health or welfare problems (Precision Livestock Farming – PLF) (Costa et al., 2013). PLF develops on-line tools to continuously and automatically monitor farm animals (Viazzi et al., 2011) during their life, without imposing additional stress to them. The PLF approach can be applied to different aspects of management, with a focus on the animals and/or on the environment, and at different scales, from the individual to the entire flock/herd (Wathes, 2009). Moreover, PLF may also be used to aid the management of some complex biological production processes, to measure the growth trend and to monitor the animal activity (Halachmi et al., 2002; Ismayilova et al., 2013; Tullo et al., 2013).

The aim of this study was to record and analyse broiler vocalisations under normal farm conditions, to identify the relation between animal sounds and their weight. The relation between Peak Frequency (PF) of sounds emitted by broiler chickens during the production cycle and their weights (both measured with an automated and a manual scale) were investigated.

2. Material and methods

Two experimental trials were carried out in an indoor reared broiler farm located in the UK; the first one took placed in June and July 2013 and the second one in August and September 2013.

The farm where the experimental trials took place was an indoor broiler farm rearing birds to the Right to Farm Act (RTFA) Assured Chicken Production (ACP) standard. The house dimensions were 61 m × 21 m; broilers are kept indoors and the stocking density allowance is less than 38 kg/m^2 for the entire production cycle. Inside the house there were 2,340 nipples drinkers and 385 feed pans available to birds. 27,940 COBB 500 chicks, of one day old, were placed inside the house at day 1 (after hatching) in both trials.

Sound recordings were collected using a professional handheld solid state recorder (Marantz PMD 661 MK II) which was connected to two different directional microphones placed at an intermediate height of between 0.4 m and 0.8 m (depending on the height/age of the animals in order to keep the same distance among animals and microphones during the entire data-collecting procedure).

The supercardioid/lobe microphone (Mic. 1) was a Sennheiser K6/ME66″ (frequency response: 40–20,000 Hz ± 2.5 dB) and it was held by a short tripod microphone stand (Quiklok A341) above the feeder.

The (cardioid) microphone (Mic. 2) was a Sennheiser K6/ME64″ (frequency response: 40–20,000 Hz ± 2.5 dB) and it was placed on a long tripod (Quiklok A492 Heavy-Duty Boom Mic Stand) directly above the drinkers.

Both the microphones were slightly inclined towards the floor in order to capture preferentially the sounds coming from the birds walking exactly in front of the microphone axis.

The recordings provided a sound image of background noise, and gave a better idea of the overall condition inside the broiler house.

The Marantz PMD 661 MK II recording machine had a large range of potential recording settings. The settings found to give the most sensitivity to bird sounds in the poultry house environment were:

Rec. Format: PCM-16, Stereo Sample Rate: 44.1 k
Level Control: Manual Low Cut: Off High Cut: Off

Animal sounds were recorded from day 1 to day 38 of the cycle production during each experimental trial.

Recordings were made for one continuous hour, using two different microphones, at regular intervals every Monday, Wednesday and Friday, with the same position of the equipment along the trial procedures. After the placement of the equipment, the operator used to leave the broiler house in order to not disturb and influence the animals behaviour. The equipment used for the recordings was taken down after each recording session and replaced before the following session. Recordings lasted for one hour in order to have enough audio data to be analysed. The time interval for the recordings was chosen at random in order to increase the variability of the samples collected.

Once a week, 50 birds were selected at random and they were manually weighted through using a manual scale in order to follow the growth changes in the birds. Throughout the production period from day 1 to day 38 house temperature and humidity levels were recorded.

The entire data collection consisted in 16 days of sound recordings for trial 1, 15 days of sound recordings for trial 2, and 6 weekly weight collections for both trials.

In total 55 h 20 min of recordings were collected and 600 birds were weighted during trial 1 and trial 2; only the audio files recorded in conjunction with the weight collection of the birds were included in the data analysis.

In total 600 sounds (50 sounds per day), chosen at random and selected from 12 days of recordings were manually labelled and analysed in this study.

2.1. Sound analysis

Sound recordings were manually analysed and labelled using sound analysis software: Adobe® Audition™ CS6. The first five minutes of recordings were not taken into account during the sound