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Research Paper

Estimation of patterns in weaned piglets' activity using spectral analysis

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The activity level of weaned piglets provides a useful tool for farmers to control animal welfare and pollutant emissions. In addition, data for weaned piglet activity can be used as an input signal in real-time ventilation control systems because of its relation to temperature and CO_2 levels. This paper characterises the daily activity pattern of piglets from 6 to 20 kg live body mass based on data obtained by a passive infrared detector on a conventional farm. Activity level of piglets was at its maximum at the beginning of the experimental period and at its minimum at the end of the period. The analysis of the Fast Fourier Transform revealed an average pattern with two activity peaks, at 10:00 h and 18:00 h, described by three cosine waves with 24-, 12- and 8-h periodicity. The Continuous Morlet Wavelet Transform revealed variations in frequency spectrum with time between the first and second half of the cycle, defining two distinct activity periods. The predominant pattern during the first half was a single-peak pattern, whereas the predominant pattern during the second half was a two-peak pattern. Accordingly, two models for the prediction of piglet activity are proposed. Animal age and mass are essential to define behaviour patterns, which explains the existence of various models in the literature and the need to perform continuous measurements to establish accurate models for predicting activity in growing piglets. Passive infrared detectors are simple and cost-effective, and allow for the incorporation of animal activity into real-time control on conventional farms.

1. Introduction

The growing intensification of commercial pig farming during the last few decades has raised concern about animal welfare and environmental issues. Actually, pork production is the second highest contributor to greenhouse gas emission from the livestock sector (Noya et al., 2016). As a result, producers are compelled to offer quality products, not only in terms of meat quality, but also in terms of the conditions of production, which must respect the environment and animal welfare. Animal activity is related to animal behaviour, welfare (Costa et al., 2014), ventilation rates and to pollutant emissions to the atmosphere (Schauberger et al., 2013).

In intensive production systems, ventilation rates are calculated based on the requirements of the animals in terms of air quality, mainly on CO_2 concentration and temperature

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(Schauberger, Piringer, & Petz, 1999). These factors are directly related to animal activity, which varies on a daily basis (Blanes & Pedersen, 2005). Animal welfare has been defined by Stevenson, Battagli, Bullon, and Carita (2014) as the avoidance of abuse and exploitation of animals by humans by maintaining appropriate standards of accommodation, feeding and general care, the prevention and treatment of disease and the assurance of freedom from harassment, and unnecessary discomfort and pain. According to this definition, many authors have related changes in animal activity and behaviour with a number of factors such as microclimate (Debrecéni, Lehotayová, Bučko, & Petrák, 2014; Olczak, Nowicki, & Klocek, 2015), environmental enrichment (Nowicki & Klocek, 2012; Scott, Taylor, Gill, & Edwards, 2006), health status (Escobar, Van Alstine, Baker, & Johnson, 2007), feed composition (Bakare, Ndou, Madzimure, & Chimonyo, 2015) or effect of weaning (Worobec, Duncan, & Widowski, 1999).

Because of the current average farm size, conducting periodic visual inspections of animal behaviour is unfeasible. For this reason, new technologies have been developed in the last few years that help farmers improve animal welfare. Cornou and Lundbye-Christensen (2008) have proposed an automated method for measuring sow activity using digital accelerometers, but the cost-effectiveness of this technique can be compromised for large groups of animals (Ott et al., 2014). Also, it is a method already employed in commercial dairy farms e.g. Smartbow (http://www.smartbow.at/en/). Activity level in groups of animals has been quantified by using non-disturbing methods such as automated video analysis (Nasirahmadi, Richter, Hensel, Edwards, & Sturm, 2015; Ott et al., 2014) or passive infrared detectors (PIDs) (Ngwabie, Jeppsson, Gustafsson, & Nimmermark, 2011; Sousa & Pedersen, 2004). Yet, both methods are used exclusively for research purposes and require further development for use in commercial livestock farms.

Image analysis of video recordings allows for the description of activity levels and other behaviour patterns. Yet, PID sensors have become an interesting tool for farm management in real time because they are inexpensive and require less processing. Pedersen and Pedersen (1995) first used PID sensors and further processed their signal to measure animal activity, understood as the movements of animals.

The activity values measured using PID sensors generate a time series. A common way of studying this type of signals is to decompose them into a set of periodic waves (Marchant, 2003). In this sense, the Fourier analysis of a time series is a decomposition of the series into a sum of sinusoidal components (Bloomfield, 2000). Fourier analysis has been widely used in time series analysis to perform a transformation from the time domain to the frequency domain (Bünger, Schrader, Schrade, & Zacharias, 2015; Youssef, Exadaktylos, & Berckmans, 2015). However, the frequency domain obtained by the Fourier transform does not provide time information; therefore, the method does not define at what instant a particular frequency arises. Since the early 1980s, wavelet analysis has become a reasonable alternative to study signals in the time–frequency domains, particularly in the presence of potential frequency changes across time.

To this end, activity data were obtained by using a simplification of the method described by Pedersen and Pedersen (1995), which used commercial PIDs without altering their output signal. The aim of this paper was to define the daily cyclic components of activity of weaned piglets during transition from 6 to 20 kg body mass, by using spectral and wavelet analysis. The objective of using the new method was to explain the daily behaviour of the animals and to determine the exogenous variables that affect animal behaviour under real farm conditions.

2. Material and methods

2.1. Animals and housing

Measurements were made during 40 days in June and July in a room for weaned piglets of a commercial pig building in Northwest Spain. A batch of 50 Large white × Landrace hybrid piglets weaned at 3 weeks of age was used for measurements. Piglets were housed in a 3.20 × 3.20 m pen, with a space allowance of 0.20 m^2 pig^{-1} (Fig. 1). The piglets entered the room at 11:00 h (UTC+2) on the 9th of June with an average mass of 6.75 kg and exited the room at 09:00 h on the 19th of July with an average mass of 19.90 kg. The ventilation system of the room was based on an individual exhaust fan with a chimney 3 m in length. The pens, composed of PVC divider panels 0.70 m in height, had fully slatted floors and a 3.20 × 0.50 m heating plate, under a PVC roof placed at a height of 0.70 m. Piglets were fed ad-libitum with compound feed provided in a double humid hopper shared by two pens. The hopper was filled daily at 01:00, 08:00, 12:00, 16:00 and 20:00 h. Pigs were fed a lacto-initiator diet (19.90% crude protein, 1.55% lysine, 2.54% crude fibre, 6.30% crude fat content) during the first five days after weaning, a prestarter diet (20.11% crude protein, 1.48% lysine, 2.58% crude fibre, 7.11% crude fat content) from 6 to 20 days after weaning and a starter diet (18.70% crude protein, 1.35% lysine, 3.02% crude fibre, 6.00% crude fat content) from day 21 to the end of the cycle. Water was supplied at a nipple drinker placed close to the feeder.

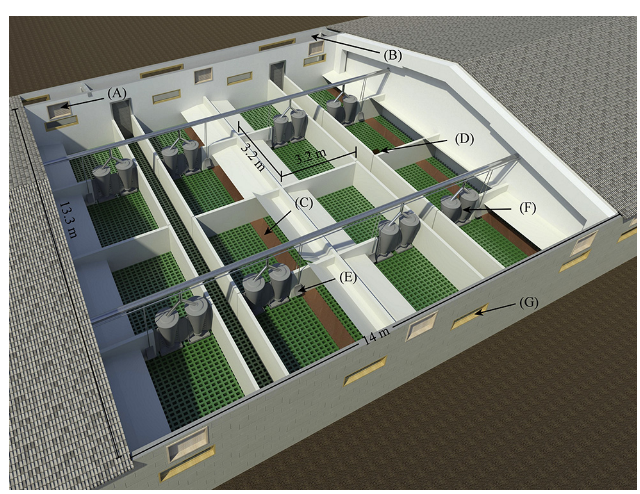

Fig. 1 – View of the weaner room where the piglets were housed. (A) Air inlet; (B) Exterior corridor; (C) Heating plate; (D) Passive infrared detector; (E) Drinker; (F) Feeder; (G) Window.

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