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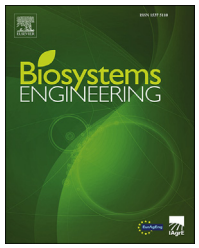

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Research Paper

Real-time monitoring of broiler flock's welfare status using camera-based technology

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Broiler activity and occupation patterns are of special interest to farmers during visual inspection. However, this is time consuming and precision livestock farming (PLF) technologies can enable the monitoring of such key flock behavioural indicators in a continuous and automated way in the house. The aim is to show how the welfare status of the poultry flock can be evaluated by real-time monitoring of activity and occupation patterns. Four top view cameras were installed in a commercial broiler house for 9 complete growing cycles. The cameras recorded images continuously and they were translated into numerical values of activity and occupation indices each minute. Three welfare assessments were performed in weeks 3, 4 and 5 of each growing cycle according to the standardised Welfare Quality® assessment protocol for broiler chickens. A real-time dynamic model was developed to monitor and forecast the time evolution of these indices and the confidence intervals for normal behaviour over each growing cycle. Statistically relevant correlations ($p < 0.05$) between the time birds spent in an alert situation during the growing cycle and the percentage of birds showing worse welfare scores were found for occupation deviations and foot pad lesions ($R^2 = 0.60$) and activity deviations and hock burns ($R^2 = 0.70$). Furthermore, these deviations can be located inside the poultry house through the relation between activity and occupation indices in specific areas associated with particular broiler behaviours, such as feeding, drinking and resting. Evaluating this relation, regular activity and occupation patterns for each behaviour were defined. This work shows that it is possible to link deviations in activity and occupation patterns of broiler flocks in commercial farms with the welfare assessment scores by human experts. This tool allows the farmer to evaluate the risk of welfare issues in the flock and to get early warnings about which bird behaviours are affected and the location in the house where these alerts are being triggered.

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1. Introduction

The global demand for livestock products will increase by 70% by 2050 (Africa & Ghanem, 2009). Chicken meat is one of the lowest cost sources of high-quality protein, and one of the most environmentally friendly meats to produce (FAO, 2014). In most countries, broiler farming systems are largely intensive and specialised, involving the growing of thousands of animals (25,000–50,000 birds per shed is typical) in an industrialised manner. Farmers are required to spend more time in administrative, technical, organisational and logistical matters than observing their animals. For this reason, Precision livestock farming (PLF) technology can support farmers in their daily routine of animal management, through monitoring farm animals continuously during their life in an automated, non-invasive, non-intrusive way (Berckmans, 2008; Tullo, Fontana, & Guarino, 2013). PLF technology can help farmers to achieve an economically viable business by ensuring high levels of productivity, health and welfare.

Activity and distribution indices reflect broilers' behaviour, which is in close relation to their welfare status (EFSA Panel on Animal Health and Welfare, 2012; Weeks, Danbury, Davies, Hunt, & Kestin, 2000). Therefore, the use of camera-based technology in the broiler house allows farmers to monitor animal behaviour in real-time. This will reduce significantly the time they need to spend in farm visits (Borgonovo, 2009). Several examples exist in the literature in which camera-based technology has been used to monitor broiler activity responses to changes in light intensity (Kristensen, Aerts, Leroy, Wathes, & Berckmans, 2006) and the correlation between collective movements of the flock and welfare scores (Dawkins, Cain, & Roberts, 2012). There are also studies in which the relation between deviations from activity and distribution patterns and the assessment of broiler chicken welfare have been investigated both at experimental and commercial levels (Aydin, Cangar, Ozcan, Bahr, & Berckmans, 2010; Dawkins, Cain, Merelie, & Roberts, 2013; Kristensen & Cornou, 2011).

Kashiha, Pluk, Bahr, Vranken, and Berckmans (2013) developed an early warning system to monitor deviations in the distribution index during the broilers' growth cycle. The aim was to detect system malfunctions in real-time in order for the farmer to be able to respond quickly and address them, preventing negative impacts on welfare or production. The system achieved 95.24% accuracy in detecting malfunctioning over the growth cycle. Febrer, Jones, Donnelly, and Dawkins (2006) and Dawkins et al. (2013) have also shown the potential of linking activity and distribution patterns exhibited by broilers with their behaviour and welfare status. One aspect missing in these types of systems is the capability of providing the farmer with information about the specific problem causing the deviation from the normal behaviour that raises the alert. For example, it is still unknown whether such systems are capable of differentiating behaviours associated with poor welfare, such as leg disorders, from technical problems such as blocked feeders or drinkers. There is no doubt that such information would help the farmer with decision making on how to address the problem.

The aim of this study is to determine whether real-time camera monitoring of activity and distribution of the flock relates with the welfare scores observed by trained assessors. Unlike previous research, the current study focusses on extracting important information in zones below each camera. The aim is to help to locate the source of the problem generating the alerts. Another objective is to evaluate the relation between the activity and occupation patterns of the flock in specific areas during feeding, drinking or resting and establish a correlation with the welfare status of the flock and how a problem affects a particular broiler behaviour.

2. Animals, materials and methods

2.1. Animals and housing

Data were collected from 9 growth cycles on a commercial broiler farm located in The Netherlands. The broiler flocks in each cycle contained between 27,300 and 27,800 birds of genotype Ross 308. The animals were housed on a concrete floored house (1298 m^2) with underfloor heating (first ten days), pad cooling and tunnel ventilation. During the rearing period, five types of feed pellets were allocated in succession in accordance with accepted commercial practice. Drinking water was provided ad libitum by nipples with cups. Daily light schemes were divided in four blocks of 6 h, with a 4 h block of light (light period) and a 2 h block of darkness in each 6 h block.

2.2. Assessments of broiler chicken welfare

In every growth cycle, three assessments of broiler chicken welfare were performed in weeks 3, 4 and 5. These assessments were performed by human experts according to the standardised Welfare Quality® assessment protocol for poultry. In this study, the welfare scores for foot pad lesions and hock burns have been selected from the assessments. Foot pad dermatitis is a contact dermatitis found on the skin of the foot, most commonly on the central pad, but sometimes also on the toes. The skin is turned dark by contact with litter and consequently deep skin lesions can result (Welfare Quality® Poultry, 2009). Hock burn is a contact dermatitis found on the skin of the caudal (back) part of the hock joint. The skin is turned dark by contact with litter and consequently skin lesions can result (Welfare Quality® Poultry, 2009). The scoring scale from 0 to 4, 0 being no presence of lesion and 4 presence of severe lesions, allows assessment of the severity of these lesions in the birds. Practically, the assessor selected five different locations in the farm where the scoring was performed. In each location the assessor selected 100 birds randomly and, following the standard procedure described for each type of lesion in the Welfare Quality® assessment protocol for Poultry, each one of these 100 birds was assessed for the different lesions. The different locations around the house were selected, not only to have a representative sample of the whole house but also to allow a comparison between the welfare scores from a specific location in the vicinity of one of the cameras installed in the house and the activity and occupation indices recorded by that

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