Impact of broiler behaviour on key production indices

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Abstract

A camera-based PLF monitoring system can be used to identify deviations in broiler flock behaviour at an early stage. The goal of this research is to identify management issues in the house and relate the outcome of a camera-based monitoring system for bird behaviour to key production indices. Three commercial broiler farms in Belgium were equipped with the eYeNamic™ camera-based monitoring system. The build-in image analysis software analyses automatically the flock behaviour by calculating indices for activity, occupation density and distribution of the broilers in the house. Feed Conversion Rate (FCR), Water-Feed Ratio (WFR) and Average Daily Growth Rate (ADGR) were calculated using production data extracted from the available controller units for 14 flocks. Between Sep 2017 and Sep 2018, several cases affecting bird behaviour were found. Deviations in behaviour were automatically identified by an early warning algorithm analysing the recorded activity, occupation and distribution indices. The Time Out Of Comfort (TOOC) was defined as the cumulative sum of these deviations per round. The correlation *r* between FCR and TOOC was 0.692. Per hour out of comfort, the feed conversion rate increased with 0.0069. Per hour out of comfort, the water-feed ratio decreased with 0.0050 (r = -0.537). Per hour out of comfort, average daily growth rate decreased with 0.1786 gram (r = -0.513). In conclusion, it was demonstrated that a continuous observation of flock behaviour allows the farmer to solve management issues as quickly as possible, which will improve the technical and economical key production indices on his farm.

Keywords: image analysis, activity, occupation, distribution, poultry, precision livestock farming

Introduction

Worldwide the demand for animal products keeps on rising, a 70% increase is predicted by 2050 (FAO, 2013). Yearly, already more than 65 billion chickens are slaughtered (FAOSTAT, 2018). To produce this amount of animals, farming methods have shifted from extensive to intensive. Broilers are today typically housed with thousands together in commercial environments making it impossible for the stakeholders to monitor all animals individual and accurate.

Precision Livestock Farming (PLF) gives an answer to these problems by monitoring the animals automatically, continuously and in real-time to help the farmer to take management decisions based on objective measured parameters (Norton & Berckmans, 2018). Camera technology have the advantage that they can measure the animals without imposing additional stress. Previous studies show that cameras can be used to observe weight (De Wet et al., 2003; Mortensen et al., 2016), broiler welfare (Dawkins et al., 2012, 2013), and lameness (Aydin et al., 2010, 2017; Silvera et al., 2017). Kashiha et al. (2013) show that deviations from activity and distribution can be used as an early warning monitoring system. In this work, a link to management problems is established. Peña Fernández et al. (2018) show that these early warnings can be linked to welfare issues in commercial broiler settings, as well.

The objective in this study is to identify issues/problems in the broiler house based on behavioural changes of the broilers monitored by a camera system and relate the time spend during these moments to key performance indices. The total TOOC from the activity, distribution and occupation is related to the FCR, WFR, ADGR.

Material and methods

Experimental data

Data were gathered on three commercial broiler farms in Belgium (Table 1). Water supply, feed supply and animal growth were automatically registered by the available control units in the farm (Fancom B.V., the Netherlands), and the data were sampled every hour and exported to a csv-file on the local farm computer. The number of dead birds and culled birds per round was on a daily basis manually entered in the farm control units by the farm personnel. The total number of dead birds over the total number of birds entering the house accounted for the flock mortality. Bird mass was automatically registered by a weighing control unit with weighing platforms in the house (Fancom B.V., the Netherlands). These data were sampled every hour from the control unit and exported to a csv-file on the local farm computer.

In total, there were 19 fattening rounds of broilers in this period, but due to power outages during the fattening rounds, or corrupt data registration in the farm computer, the data of five fattening rounds were not available for analysis. For data analysis, 14 complete fattening rounds were used.

Table 1: Overview of farm specifications

	Farm A	**Farm B**	**Farm C**
Floor area	2400 m^2	1476 m^2	1280 m^2
Max. number of birds	52000	32000	28000
Number of feeder lines	5	4	4
Number of drinker lines	6	6	5

Key Production Indices were calculated from the gathered farm data. The length of the fattening period (FP) was determined from the brooding day until the house was cleared from all birds. Water Feed Ratio (WFR) was calculated as the ratio of water and feed supply of the fattening round at the end of the fattening period. Average Daily Growth

Rate (ADGR) was calculated from the brooding weight of the animals, the end weight of the birds at clearance and the length of the fattening period.

The broiler houses were equipped with a camera-based monitoring system for bird behaviour analysis (eYeNamic™, Fancom B.V., the Netherlands). The system consisted of four cameras that were installed in top-down perspective from the house ceiling, approx. at a height of 4m. The cameras were installed in a 2x2 grid in the house at 1/3 and 2/3 of the length of the house, and at 1/3 and 2/3 of the width of the house. In this layout, the cameras were covering a substantial part of the floor area in the width of the house. Each camera covered a 4m by 10m area of the floor space. It was advised to cover all water and drinker lines in the field of view of the cameras. The system automatically translated the recorded images into data on bird activity levels, bird occupation density levels in the image and bird distribution in the house. These data were sampled every minute by the farm management software program on the local farm computer, and per camera unit stored into a csv-file. For the data analysis, the data per camera unit were aggregated on house level, resulting in the average activity level of the birds in the house per minute, the average occupation density of birds in the house per minute and the distribution index of birds in the house.

Extraction time out of comfort

An early warning algorithm was developed and tested in this experiment. The early warning algorithm used the average value in the last 48 hours as the norm, and the average value in the last 24 hours as the signal. The limits for normal behaviour were calculated from the norm values and the standard deviation of the value in the last 24 hours. When the signal was out of the limits for normal behaviour, bird behaviour was considered to be out of comfort. This procedure was done on all three eYeNamic variables (activity, occupation and distribution) and with a sliding window procedure of 24 hours , updated every minute. In the analysis for this work, the total number of minutes out of comfort were aggregated per fattening round, and these data are presented in the results section and in Table 2.

Results and Discussion

For every individual production round in the experiment, the total TOOC was calculated (Table 2). For the 7 production cycles in farm A, this time ranged between 1777 minutes and 3314 minutes (29.6 h and 55.2 h). Farm B (5 production cycles) showed more variation with a minimum TOOC of 955 minutes (15.9 h) and a maximum of 3474 minutes (57.9 h). Farm C, with only 2 production cycles, exhibit a higher TOOC relative to the other farms, with 3193 minutes (53.2 h) and 4168 minutes (69.5 h).

All production cycles ranged between 40 and 43 days. The WFR ranges from 1.51 to 1.99 and is higher in farm A than in farms B and C. The FCR ranged between 1.43 and 1.84, except for an outlier of 1.84 farm B shows the lowest FCR. The ADGR was the lowest in farm C, 48.7 grams, and the maximum was 64.3 grams measured in farm B. Mortality ranges from 1.55 to 4.03. More details can be seen in Table 2.

Table 1: Overview of the key production data in the three broiler farms gathered during the experimental period.

Farm	TOOC	WFR	FCR	FP	ADGR	mortality
A	2239	1.76	1.63	42	57.9	2.14
A	3314	1.76	1.54	42	62.8	1.55
A	2465	1.74	1.56	42	60.8	3.18
A	2309	1.75	1.57	42	60.9	1.70
A	1777	1.92	1.64	42	58.1	4.03
A	1798	1.99	1.57	44	57.2	2.58
A	2109	1.88	1.62	43	56.5	1.99
B	3474	1.51	1.84	43	53.3	2.63
B	2048	1.63	1.43	40	64.3	3.83
B	955	1.67	1.47	40	63.9	3.38
B	1294	1.75	1.47	42	61.2	2.13
B	1952	1.67	1.51	41	58.9	2.70
C	3193	1.60	1.83	43	48.7	3.57
C	4168	1.53	NA	43	NA	3.79

TOOC = Time Out of Comfort [minutes]**; WFR** = Water-Feed Ratio [-]**; FCR =** Feed Conversion Rate [-]**; FP =** Fattening Period [days]**; ADGR =** Average Daily Growth Rate [grams]

This work is an attempt to relate key production indices to the TOOC, independently from other factors such as broiler quality, farm, and feed diet. Figure 1 shows the relation between the FCR and the TOOC. A positive relation (R^2 = 0.479) can be seen between both variables. This indicates that higher the TOOC for the birds, higher the FCR, thus more feed is needed to grow the birds. Hence, the eYeNamic system can give an indication of the FCR ratio. The best fit linear regression model is $FCR = 1.16 \cdot 10^{-4}\, TOOC + 1.33$. This can be explained as the feed conversion rate increasing by 0.0069 per hour spent out of comfort.

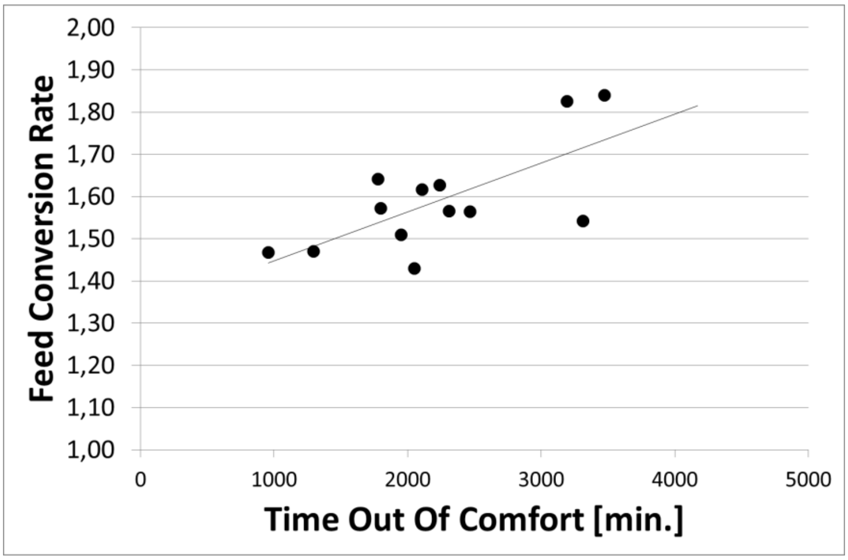

Figure 1: Graphical overview of the linear relation between time out of comfort and Feed Conversion Rate.

Similarly, a negative relation is found between the TOOC and the WFR (R^2 = 0.289) and the TOOC and the ADGR (R^2 = 0.263). Figures 2 and 3 display a visual description of this linear regressions.

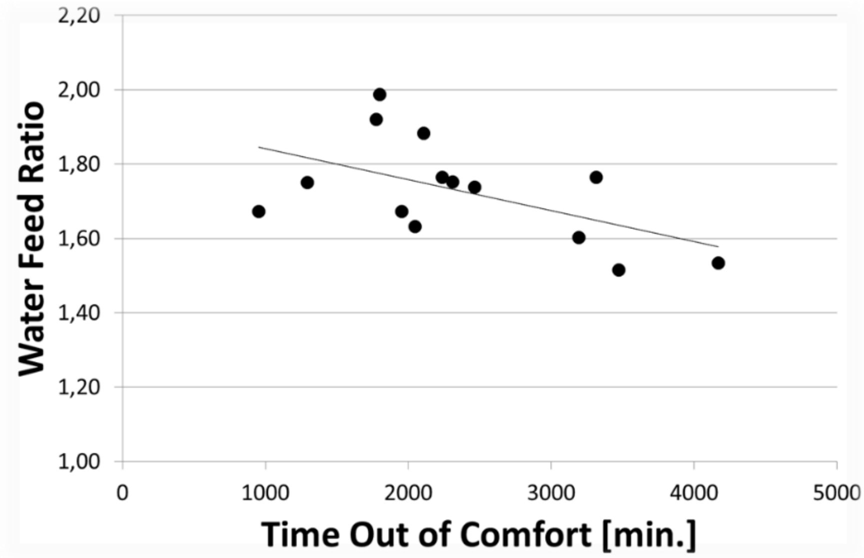

Figure 2: Graphical overview of the linear relation between time out of comfort and Water Feed Ratio.

The best fit linear regression model to relate TOOC and WFR is $\boldsymbol{WFR = -8.33 \cdot 10^{-5}\, TOOC + 1.92}$. This indicates that per hour out of comfort, the water-feed ratio decreased with 0.0050 (r = -0.537).

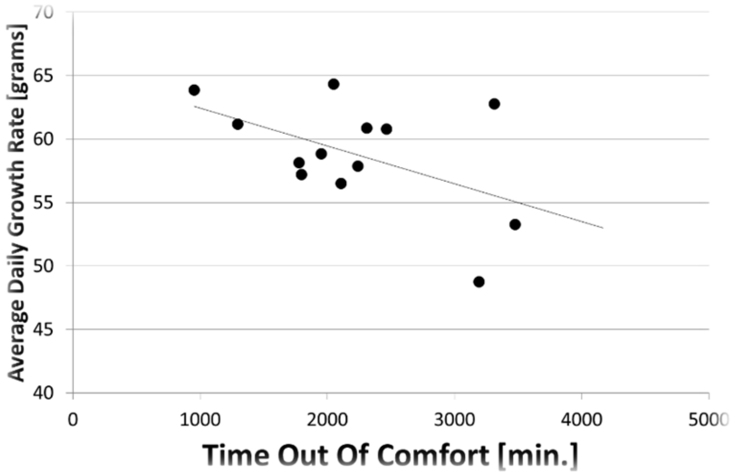

Figure 3: Graphical overview of the linear relation between time out of comfort and Average Daily Growth Rate.

Correspondingly, the best fit linear regression model to relate the TOOC and the AGDR is $\boldsymbol{ADGR = -2.98 \cdot 10^{-3}\, TOOC + 65.4}$ (R2 = 0.263).Therefore, per hour out of comfort, the average daily growth rate decreased with 0.1786 gram (r = -0.513). In table 3, a summary of the correlations and hourly increments is displayed.

Table 3: Correlation coefficient of the three selected production indices in relation to Time Out of Comfort and the hourly incremental values

	WFR	FCR	ADGR
Correlation coefficient	-0.537	0.692	-0.513
Hourly increment	-0.0050	0.0069	-0.1786

In the work of Dawkins et al. (2012), it is found a negative correlation between optical flow features, such as the mean value, variance, skew and kurtosis, and the mortality rate and culled birds in commercial broiler farms. This indicates that deviations in the optical flow features has a negative impact in broilers' mortality and culling. In this work, similar results are found in relation to other key production indices, such as WFR, FCR and ADGR. An increment in the TOOC throughout the fattening cycle has a negative impact in the key production indices monitored.

The TOOC in this study is estimated at broiler house level and then linked to the key production indices. This is done similarly as in the work of Kashiha et al. (2013). On it, activity, occupation and distribution indices are also averaged first for the whole house and then deviations are monitored to raise early warnings which lead to a statistically relevant relation to management problems. It is expected that such management problems have an impact in the key production indices. Thus, it seems feasible that the relations which are found in this work between the TOOC and the key production indices may be related to such management issues. However, in the work of Peña Fernández et al. (2018) is shown that, in order to establish statistically relevant relations between these early warnings, expressed as percentage of time spent in an alert situation, and flock welfare scores, it is needed to work at individual camera/area level in the house. Therefore, as it is expected that the presence of welfare issues affect the key production indices of a flock as well, it should be explored if also estimating the TOOC at individual camera level may lead to a strength of the relations with the key production indices achieved in this study.

Conclusions

Data were gathered from commercial broiler farms. Out of the total 19 fattening rounds in the observation period, only 14 fattening rounds (74%) resulted in complete data. Data analysis showed that the correlation r between FCR and TOOC was 0.692. Per hour out of comfort, the feed conversion rate increased with 0.0069. Per hour out of comfort, the water-feed ratio decreased with 0.0050 (r = -0.537). Per hour out of comfort, average daily growth rate decreased with 0.1786 gram (r = -0.513). These results demonstrate that a continuous observation of flock behaviour allows the farmer to solve management issues as quickly as possible, which will improve the technical and economical key production indices on his farm.

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