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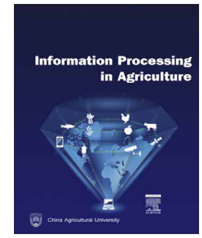

Detection of flock movement and behaviour of broiler chickens at different feeders using image analysis

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A B S T R A C T

The behaviour of broiler chickens has been extensively studied as a function of stocking density and environmental conditions, but limited information was reported in the scientific literature about the effect of feeder type on birds' feeding process. The main objective of this study was to assess the effects of three different feeder types in relation to the birds' behaviour in its surroundings. The analysed feeders were: tube-type with partition grid (F1); tube-type without partition grid (F2); and automatic type with partition grid (F3). The considered variables were: occupied area (OA); activity index (AI) (flock movement); total birds presented in the area (TB); and birds effectively eating (EE). OA and AI were calculated by computational image analysis while TB and EE were manually measured. The results indicated that the feeder type could have influenced the birds' behaviour regarding to OA ($R^2 = 0.56$), TB ($R^2 = 0.48$), and EE ($R^2 = 0.40$), but AI ($R^2 = 0.01$) was not found to be directly influenced by the feeder type. A higher percentage of birds effectively eating were found in F2 (86.4%), which was the one with the largest free area to access the feed. Similar average number of total birds was found in F1, but with a lower percentage of individuals effectively eating (63.3%), which means that birds were nearby this feeder performing other behaviours. Since the assessed feeders were in the same house under the same conditions, it can be suggested that not only the free area to access the feed but potentially the design of feeders could have influenced the birds' feeding preference. The real beneficial effect of the adoption of partition grid on feed trays is still uncertain, and it is also unclear whether the financial value of reduced wastage would compensate the possible reduction in feed intake.

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1. Introduction

The feed is the most significant input in poultry production and has an over-riding effect on the financial viability on the production cycle [1,2]. Past and recent studies have been carried out in order to improve the feeding efficiency of broiler chickens in areas like ingredients' selection and feed processing methods [3,4], and the effect of feed particle size on flock performance [5–8] and gut development [9–11], but little is reported on literature about the impact and efficiency of different feeders on birds' feeding behaviour.

At the rearing environment, it is essential that feeders and drinkers be properly arranged and well managed. It has been suggested that the food sources distribution influence broiler chickens space use patterns. Besides, these patterns are not fixed but they can rather be adapted according to the dominant environmental conditions [12]. Moreover, the enclosure size has more influence on birds' movement and space use patterns than only stocking density itself [13]. It has been also suggested that design features like size, location, geometry, spacing and angle of feeders can affect the behaviour of animals [14,15]. Partition grids over feed trays are extensively used in the poultry industry as it is believed to promote a better distribution of the birds around the feeders and reduce feed competition and wastage [16].

Computational image analysis methods have been used to monitoring flock motion patterns of broiler chickens in different situations. It can be an efficient method to estimate the level of animals' welfare to improve flock management by aiding predictions for further decision making [17–23]. This study aimed to use computational image analysis techniques in order to access the behaviour of broiler chickens in a commercial house, when interacting with three different types of feeder, considering the flock motion, floor occupied area by the birds' body and eating behaviour.

2. Material and methods

2.1. Birds and facilities

The study was carried out in a conventional Brazilian commercial broiler building (100 m × 8.5 m), housing 14,000 broilers (Ross® genetic strain) with a stocking density of 16 birds/m^2 from 17 to 24 days of old, which is considered the steepest growth phase period for broilers [24]. Manual feeders were used during the first week, but after the second and third week both tube and automatic feeders were simultaneously used with bell-type drinkers. Axial fans (with built-in foggers) and side curtains were used for ventilation control. The concrete floor was covered with fresh pine shavings as bedding substrate.

2.2. Accessed feeders

The evaluated feeders were the (1). Fênix feeder (F1), which is a prototype not available commercially [25]; (2). manual tube-type feeder (F2) and; (3). automatic-type feeder (F3). Both F2 and F3 are available commercially. Both F1 and F3 had a partitioning grid attached to the feed trough, controlling the access of the birds to the feed. Birds fed on F2 feeders had full access to the feed. Therefore, each equipment presented distinct configuration in regards to access to feed (Table 1). The potential effect of the height of the feed trough edge on feeding patterns was not considered in this study.

2.3. Experimental procedure

Direct video footage was recorded in pairs (F1 versus F2; F1 versus F3) using a tripod with two video cameras attached from above (Sony DCR-TRV330®, Sony Electronics Inc., Park Ridge, NJ, USA; and JVC GR-D90UB®, Victor Company of Japan, LTD, Yokohama, Japan; Fig. 1). Analyses were carried out with the same amount of sampling for all feeders. The total floor area covered by the image was approximately 1.0 m × 1.5 m, with the feeder located at the centre. Each sample consisted of a 55 min of video footage twice a day, between 8:30 h and 10:30 h and 14:00 h to 16:00 h. Data were digitalized for further computational image analysis. Ambient variables were recorded at the centre of the pair of feeders at 30 cm above the floor using a HOBO® H8 data logger (Onset Computer Corporation, Inc., Bourne, MA, USA) at the sampling rate of 30 s. The variables monitored were dry bulb temperature (°C), relative humidity (%), and light intensity (l×).

2.4. Image analysis

The 55-min video sample was truncated to 25-min sample that was analysed at a one-minute interval. The first 10 min of the video footage was deleted to avoid the inclusion of the 'non-typical' behaviour of the birds in the analysis caused by the human presence while setting up the cameras. It was established a rectangular region (180 × 170 pixels; approximately 0.5 m^2) in the area of the feeders to carry out the analysis. The following variables were considered (Table 2): occupied zone (OA), activity index (AI), total birds presented in the area (TB), and total birds effectively eating (EE). OA and AI were automatically calculated using Matlab® software (MathWorks, Inc., Natick, Massachusetts, USA) while TB and EE were manually calculated by counting the individuals on the monitor.

To determine the OA each frame was binarised (Fig. 2b) based on a threshold level found using Otsu's method [26]. This image then was subjected to a morphological erode operation to minimize background noise (Fig. 2c). This process determined the area the birds occupied (white pixels) in relation to the background (black pixels), i.e. the ratio between the total area and the number of white pixels (corresponding to the birds). Thus, the actual approximate area occupied by birds could be found multiplying the ratio by 0.5 m^2. The AI was calculated based on the technique reported by [27], in which an algorithm analyse images to calculate activity, occupied zone and boundary of the animals according to the behavioural response to the referent micro-environment.

2.5. Statistical analysis

General Linear Model (GLM) procedure was adopted to assess the relationship between the variables (OA, AI, TB and EE) and

Table 1 – External dimensions and partitioning grid characteristics of the feeders: Fênix (F1), Tube (F2) and Automatic (F3).

Feeder features	F1	F2	F3
			
Feed trough diameter (cm)	36	42	33
Feed trough perimeter* (cm)	11,304	13,188	10,362
Number of grid divisions	9	NA	14
Free area to access feed (cm^2)	240	795	693

NA = not applicable.
* Refers to the continuous line of the external edge boundary of the feeder.

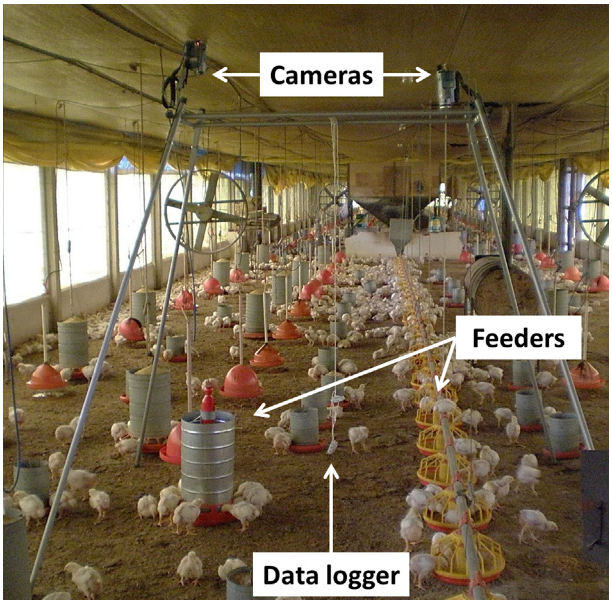

Fig. 1 – The arrangement of data recording equipment in the broiler house.

the feeders (F1, F2 and F3), in which temperature and light intensity were used as covariates. The statistical tests and graphics were carried out through Minitab 15® software (Minitab Inc., Pennsylvania, USA).

3. Results and discussion

GLM analysis (Table 3) indicated that OA ($R^2 = 0.56$), TB ($R^2 = 0.48$), and EE ($R^2 = 0.40$) were possibly influenced by feeder type. However, AI ($R^2 = 0.01$) was not affected by the feeders in this specific study. The percentage of birds that were effectively eating in F2 (EE = 86.4%) was higher than F1 (EE = 63.3%), despite the fact that the average number of total individuals (TB) were similar in both of them (F2 = 10.0; F1 = 8.8). Interestingly is that OA was higher for F1 even with lesser individuals, in which was expected that more individuals would represent a larger occupied floor area. On average, lesser birds stayed nearby automatic-type feeder (F3 = 3.7), but 79.7% of them were effectively eating.

The higher percentage of birds eating in F2 could be explained by the easiness to access the feed, as previously suggested by [16], since this type of feeder without partition grid presented the larger free area in the feed tray (Table 1). The second largest open area to access the feed was in F3, but the small number of birds presented in its surroundings could be due to a thin layer of feed, that meant more efforts by the birds to reach the feed. This was a standard procedure in the property in this particular growing phase to diminish wastage by the birds during feeding. The feed access area for F1 was remarkably smaller due to the shape of the partitioning grid, but a similar amount of individuals as in F2 was observed. More birds in F1 were performing behaviours other than eating, such as foraging, preening, stretching, dust-bathing and laying (resting), which are considered to be 'natural behaviours' [30], and good indicators of well-being for broiler chickens [28–30]. Moreover, broilers can stay resting up to 70–80% of their time [31,32]. It can be suggested that the birds somehow felt comfortable by staying nearby F1, even if fewer birds were effectively eating compared to the other feeders. Some studies suggest that size, location, geometry, spacing moreover, angles can impact the feeding behaviour of animals [14,15], and also the height of the feeder edge on the preferences of broiler chickens [33]. Despite the height of the feeders was not considered in this study, it can be suggested that not only the available free area could have influenced the birds' preference for a certain feeder, but potentially also its design, and/or partitioning grids' format.

Table 2 – Description of assessed variables.

Variable	Description
Occupied area (OA)	An index relative to the occupied area by the birds Surrounding the feeder
Activity index (AI)	An index relative to the flock movement of 2 successive frames
Total birds (TB)	The total number of specimens present in the scene
Effectively eating (EE)	The total number of specimens present in the scene that were effectively eating

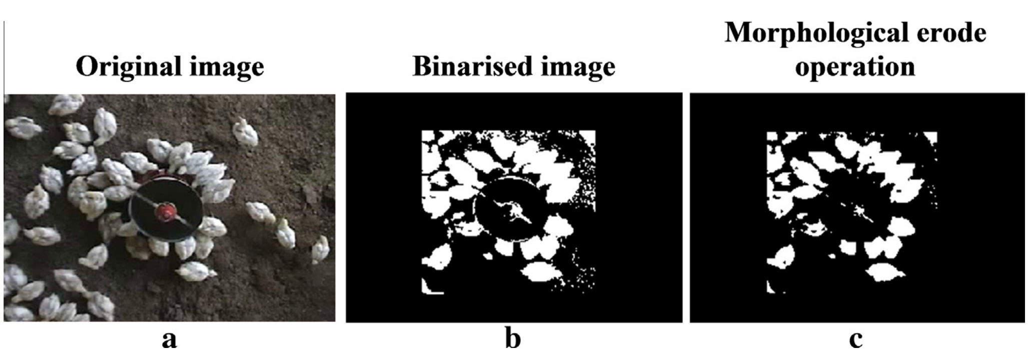

Fig. 2 – Illustrative pictures of processing stages for determining occupied area.

Table 3 – The mean and standard error and the General Linear Model (GLM) results (R^2; P-value) for occupied area (OA), activity index (AI), total birds (TB), effectively eating (EE), and the corresponded percentage of EE for each feeder type.

Variable	F1	F2	F3	R^2	P-Value
OA	0.29 ± 0.006	0.24 ± 0.003	0.11 ± 0.004	0.56	0.000
AI	0.02 ± 0.001	0.02 ± 0.000	0.02 ± 0.000	0.01	0.002
TB	8.8 ± 0.2	10.0 ± 0.1	3.7 ± 0.2	0.48	0.000
EE	5.6 ± 0.2	8.6 ± 0.2	3.0 ± 0.2	0.40	0.000
EE (%)	63.3	86.4	79.7	–	–

Another explanation for our findings could be the social facilitation. Rather than being a simple attraction of hungry birds to the feeders, there is a strong indicator for the arrival of more birds and their trend to stay for longer periods in the crowded areas, although this does not necessarily mean that more feed will be consumed [34]. This tendency could explain the fact that TB was slightly higher in F2 than F1, but with a lower OC. The birds effectively eating in F2 were more crowded than in other feeders, so their body part overlapped others and the floor area occupied by the birds were smaller. In F1, there were more birds performing other kinds of behaviour than eating, such as foraging, preening, stretching, dust-bathing, resting, and others. These behaviours represent larger floor occupied area by the birds' body. This fact is supported by [35], which used techniques of image processing and computer vision to identify different body shapes of broiler breeders, according to their most typical behavioural expressions.

Given the preliminary nature of the present study, it could not be established with a high degree of certainty that the feeder type itself influenced the birds movement in its surroundings ($R^2 = 0.01$ for AI). Also, the correlation between AI and temperature, relative humidity, light intensity, TB, EE, OB was not significant ($P > 0.05$). GLM analysis indicated that AI was only influenced by OA ($R^2 = 0.74$; $P = 0.001$). The remaining 0.26 of the R^2 could be explained by the increase of the number of birds (higher OA) that were not moving (less AI). Thus, it cannot be asserted that the feeder type directly influenced the flock activity (AI) in this particular study. Furthermore, it is believed that the methodology used by [19] to measure the birds' activity index might be more accurate than that used in the present study [27], so further analysis is desirable in order to improve the model. The optical flow analysis it is another methodology to access flock movement [18–22], which has the potential to be adapt for the circumstances of this study.

The real beneficial effect of the adoption of partition grid on feed trays is still uncertain, and it is also unclear whether the financial value of reduced wastage would compensate the possible reduction in feed intake. The adoption of a more accessible feeder (via the elimination of partition grids) might increase feed wastage, but it could result in a higher feed intake and, thus, an overall improvement on productivity indices.

4. Conclusions

The different feeder types influenced the broiler chickens' behaviour regarding to occupied floor area and individuals that were effectively eating (and not nearby feeders performing other behaviours), but the activity index (flock movement) was not directly influenced by the feeders. A higher percentage of birds effectively eating were found in the feeder with the largest free area to access feed (tube-type without partition grid), but the same number of individuals was presented in the feeder with less open space to access feed (tube-type with partitioning grid), and generally lesser birds stayed nearby automatic feeder (with partition grid). These results suggest that not only the space to access the feed but the design of feeders potentially influence the birds' preference for feeding and/or just staying nearby feeders.

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