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Evaluation of airflow movement within a broiler shed with roof ventilation system during summer

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Abstract. Indoor conditions of broiler sheds are influenced by environmental parameters such as temperature, relative humidity and air movement. Air temperature and relative humidity contribute mainly to the heat stress in broilers and are controlled by air velocity. Roof ventilated broiler sheds are designed to mechanically force air into a confined space through a negative pressure. They have bottom-hinged inlets and roof fans. In summer, the air inlets of the broiler sheds are usually opened fully, in addition to the mechanical fans in 100% operation to ensure broiler chickens are properly ventilated to prevent heat stress. Surprisingly, no information on the practice of farmers during summer in roof ventilated broiler shed is available. Hence, this work was carried out to assess air movement within a roof ventilated broiler shed during summer. The results of this work indicated that opening the inlets fully during summer may not improve the air movement at the animal microclimate. The average air velocities at the animal microclimate were found to be between 0.30 and 0.40 m s^{-1} in an empty broiler shed compared to the occupied broiler shed which varied from 0.10 and 0.20 m s^{-1}. Therefore, this work has shown that airflow at the birds' microclimate inside the broiler shed are mainly influenced by the birds themselves, inlet opening technique and distance from the sidewall.

1. Introduction

During summer, the inlets and doors of poultry sheds are opened fully to permit higher airflow into the broiler shed. This act, according to the reports [1, 2, 3] might not produce a clear rise in airflow at the animal microclimate. It possibly would hinder the airflow system to supply adequate air velocity to animal microclimate. This could result in reduced air distribution reaching the animal occupied zones [2]. Thus, a clear understanding of the airflow distributions inside the roof ventilated broiler shed, with fully opened inlets and mechanical fans operating at 100% capacity, is important when assessing the ventilation effectiveness and also defining the thermal comfort of broilers within a confined shed in summer.

In almost all commercial broiler sheds, farmers operate the fans at 100% capacity with the inlets also opened fully to make sure that maximum air velocity enters into the shed. The reports on the summer technique, mostly practiced by the poultry growers, is scarce, especially as related to the roof ventilated broiler shed. However, there are detailed documentations on the cross ventilated and tunnel ventilated broiler sheds. It is therefore useful to study the air movement inside the empty and occupied broiler shed with roof ventilation system to understand the variations in air movement at different places within the broiler shed.

Consequently, this work was conducted to examine the environment in which adult broilers are raised inside the roof ventilated broiler sheds and the relationship between the environments and the cooling provided by the shed. Hence, the objectives of the work were to: assess the effect of fully opened inlet and 100% capacity working mechanical fans on the air velocity distributions inside the roof ventilated broiler shed; and study the effect of broilers and the indoor equipment in the broiler shed on air movement in the animal microclimate.

2. Materials and methods

2.1 *Broiler shed*

The work was carried out in a broiler shed located in poultry unit of Harper Adams University, Newport, Shropshire, UK on latitude 52. 7795 º N and longitude 2.4271 º W (figure 1). The shed contains twenty-four inlets dimensioned 0.52 m (length) and 0.21 m (width). There were 24 inlets in the shed with each sidewall containing 12 inlets. The roof of the shed contains five fans of 0.63 m diameter which were equally spaced. The inlets are bottom-hinged operated inlets, controlled by an environmental control system (CLIMATEC). The same control system regulates the speed of the roof fans. In summer, the roof fans are 100% operated and the inlets also fully opened to ensure maximum airflow enters the shed.

Figure 1. A sidewall inlet and roof ventilated broiler shed.

2.2 *Airflow measurement*

3D ultrasonic airflow sensors (WindMaster - Part 1561-PK-020), produced by Gill Instrument, UK, were used to measure air velocity inside the broiler shed. The sensors have ability to measure air

velocities from 0 to 50 m s^{-1}, it has 0.01 m s^{-1} resolution and 1.5% RMS at 12 m s^{-1} accuracy. Furthermore, the sensors, according to [4], are capable of measuring and recording air velocity components (u_x, u_y and u_z) at 20 Hz. The measured air velocities were recorded on a PC with a software, known as WindView, provided by the manufacturer of the airflow sensors.

2.3 *Air velocity measurement inside the broiler shed*

2.3.1 Broiler shed without birds. Air velocities, inside the empty broiler shed, were measured and recorded at various heights such as; (1) an average height of broiler (0.20 m), (2) inlet height (1.70 m) and (3) eave height (2.55 m) above the floor and at different locations from the sidewall inlets (1.0, 3.0, 5.0, 7.0 and 9.0 m). Details of the measurement locations and the heights, within the empty broiler shed, are shown in figure 2. Air velocity measurement obtained through the ultrasonic anemometers were recorded on a PC with the WindView software over a period of 10 minutes.
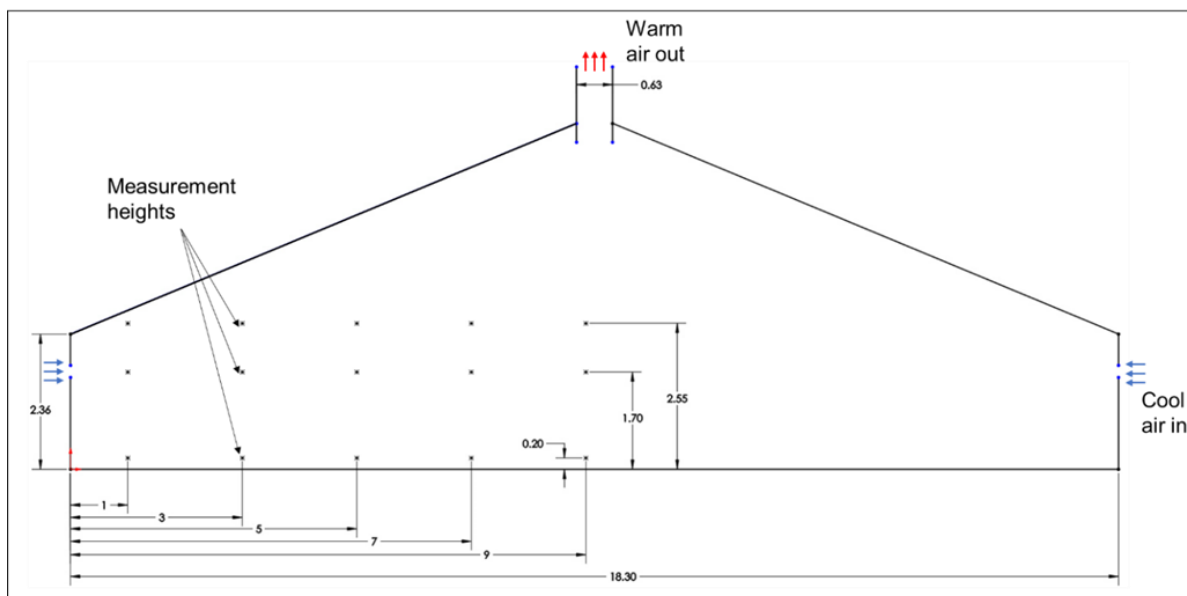

Figure 2. Air velocity measurements inside an empty broiler shed (All measurements are in metres).

2.3.2   Occupied broiler shed. Another work was also carried out to assess the air velocity distributions in the animal occupied zones inside the broiler shed filled with broiler dummies (plastic footballs). A certain area of about 20 m^2, inside the shed, was filled with wood chips (0.05 m thick), balls, feeders and drinkers. During a research work, there may be some uncertainties when working directly with livestock. Therefore, scientists have resulted in utilising non-living objects to replace animals. In this work, broiler chickens were replaced with plastic balls since it has been reported that they have similar characteristic diameter to that of broilers [5]. Commercially produced broiler chickens, attain an average body weight of 2.0 to 3.0 kg within 38 to 42 days from day-old [6]. According to [7], a characteristic diameter ($D_{poultry}$), based on the bird's body weight ($M_{chicken}$) of could be estimated using Equation 1.

$$D_{poultry} = 0.131 \times M_{chicken}{}^{0.33} \tag{1}$$

This work used 2.6 kg as an average body weight of broiler chickens and the characteristic diameter was estimated as 0.18 m and the balls were inflated appropriately. In the Europe, a stocking density of 33 kg m^{-2} is acceptable in broiler production to prevent poor welfare of birds as long as there is a provision of

a minimum environmental conditions [8, 9]. In this work, a stocking density of 33 kg m^{-2} of broiler dummies (balls) was considered and used to assess the effect of broilers on the air velocity distributions in the animal occupied zones.

Air velocities in the animal occupied zones were obtained with ultrasonic anemometers at 0.20 m above the floor and at different locations (1.0, 3.0, 5.0, 7.0 and 9.0 m) from the air inlets on one of the sidewalls. The arrangement of the balls and the sensors are presented in figure 3.
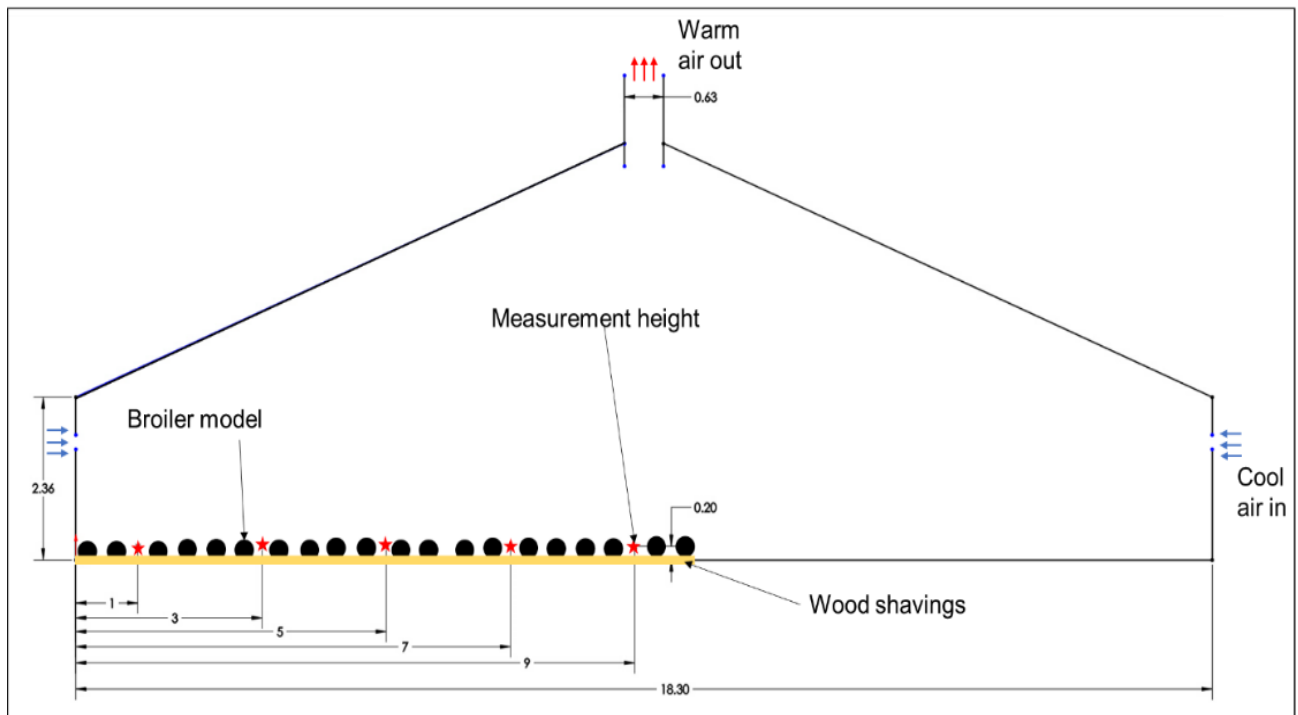

Figure 3. Assessment of air velocity distributions inside an occupied broiler shed (All measurements are in metres).

2.4 *Airflow mathematical expression*

The average air velocity (ū) was calculated from the measured instataneous air velocities using Equations 2 and 3 [10].

$$\bar{u} = \frac{1}{\delta t} \int_{t}^{t+\delta t} u \, dt \qquad (2)$$

$$\bar{u} = \sqrt{\overline{u_x}^2 + \overline{u_y}^2 + \overline{u_z}^2} \qquad (3)$$

where $\boldsymbol{u}$ (m s^{-1}) = instantaneous air velocities, $\boldsymbol{t}$ (s) = time, $\overline{\boldsymbol{u_x}}, \overline{\boldsymbol{u_y}} \ \boldsymbol{and} \ \overline{\boldsymbol{u_z}}$ are the components of the air velocity.

2.5 *Analysis of data*

In the work carried out inside the broiler shed without birds, a factorial experimental design of 5x3 was adopted. This means there were 3 heights (0.20, 1.70 and 2.55 m) above the floor and 5 locations (1.0, 3.0, 5.0, 7.0 and 9.0 m) from the inlet on one of the sidewalls. For the work in the occupied broiler shed, air velocity measurements were acquired at 0.20 m above the floor (bird's microclimate) and at five

locations (1.0, 3.0, 5.0, 7.0 and 9.0 m) from the inlet and the studies were repeated three times. Airflow measurements were processed with the Equations 2 and 3 and analysed with SAS software (JMP version 14). The air velocities measured in the broiler shed were analysed using ANOVA analysis. All the analyses were done on 5 % level of significance.

3. Results and discussion

3.1 *Airflow within the empty broiler shed*

The average air velocities obtained at 0.2 m (birds' microclimate), 1.70 m (inlet height) and 2.55 m (eave height) are presented in figure 4. From figure 4, the average air velocities obtained at bird's microclimate at 1.0 m and 3.0 m from the inlet differed from that acquired at the other measurement heights (inlet and eave heights). However, there were no much difference between the air velocity acquired at all the measurement heights at 5.0 m to 9.0 m from the inlets. As revealed in Figure 4, the differences between the air velocities were more noticeable in the regions closer to the sidewall (1 and 3 m from the inlets). A closely related results have been shown by [11] who showed that air movement in the animal microclimate at regions closer to the inlets is usually lesser than air velocities obtained at other locations from the inlets.

The ANOVA conducted indicated that there existed a significant difference in the average air velocities between the heights (0.20, 1.70 and 2.55 m) at 1.0 m and 3.0 m from the inlets. However, no significant difference in the average air velocities between the heights 0.20, 1.70 and 2.55 m at 5.0 m to 9.0 m from the inlets was noticed.
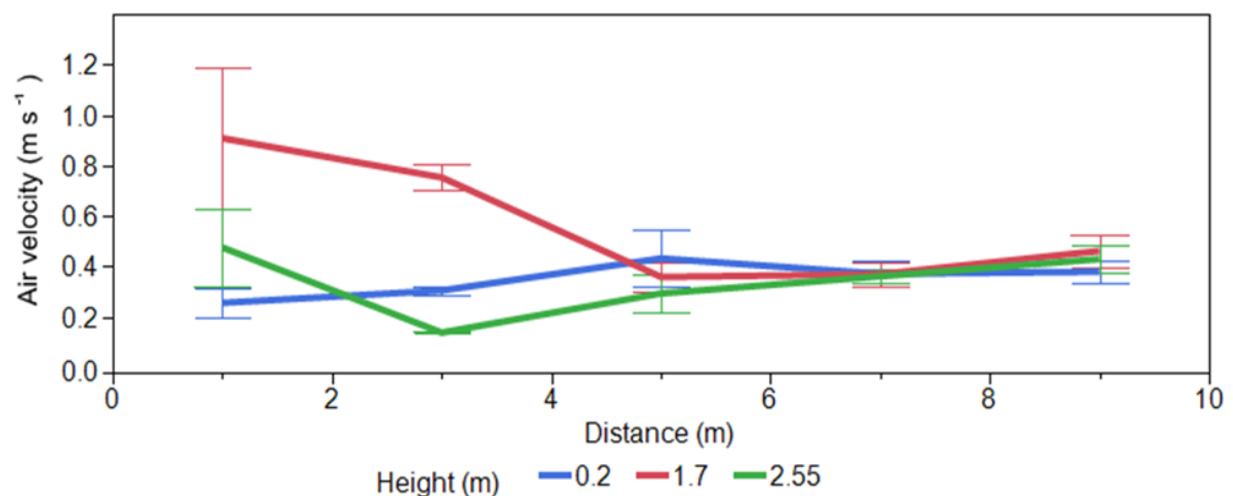

Figure 4. Air velocities measurements inside the empty broiler shed.

3.2 *Air movement at the animal microclimate within the broiler shed occupied with birds*

Air velocities measured at 0.2 m above the floor when mechanical fans were in full operation and the inlets fully opened are presented in figure 5. The average air velocities acquired at all the locations varied from 0.10 to 0.20 ms^{-1}. This shows that the air velocity is too low to provide a cool environment for broilers chickens during summer. It could be detrimental to broiler chickens if they are kept in such a poor ventilated environment. [12] showed that the environments in which broilers are kept during the summer are not suitable because of low and non-uniformity of air velocity in the animal occupied zones. The negative effect of poor ventilation is that birds would migrate from the regions with low air movement to areas with an improved air velocity. This has been shown to result in high mortality in the broiler production during summer [13].

The ANOVA analysis showed that there were no significant different between the mean air velocities obtained at 1.0 m and 9.0 m from the inlets. Likewise, the analysis indicated that mean air velocity acquired at 3.0, 5.0 and 7.0 m from the inlets were not significantly different from one another.
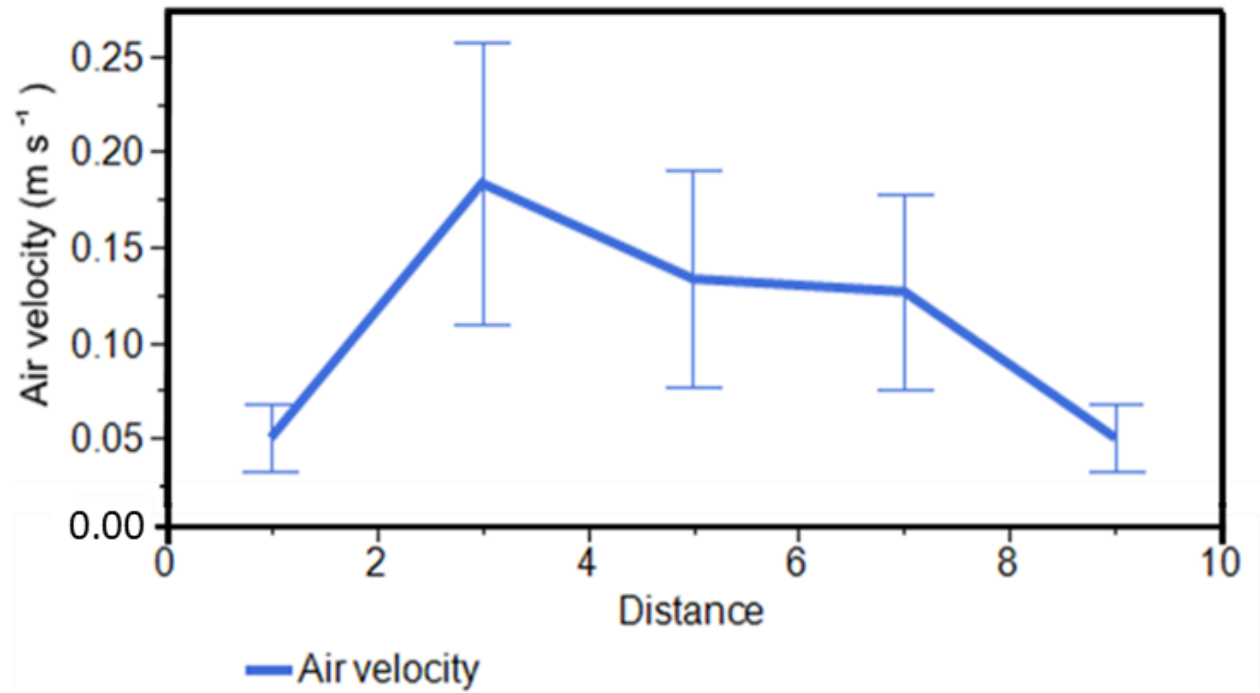

Figure 5. Air velocities at 0.20 m above the floor.

4   Conclusion

This work has identified that air movement at the broilers' height could be determined by the inlet opening size, the locations from the inlet and the conditions (empty or occupied) under which the work was carried out in the broiler shed. Air movement in the occupied broiler shed were lower than the air velocities acquired inside the broiler shed without birds. This indicates that assessing the internal conditions of livestock sheds with the measurements acquired when the animal sheds are empty is not appropriate. Therefore, it is recommended that the internal conditions of livestock sheds be adequately assessed when the sheds are filled with live animals to properly understand the conditions under which animals are kept.

Acknowledgment

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