Evaluation of heat stress experienced by broilers raised in 3-tier cages in a hot-humid tropical environment

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ABSTRACT: Heat stress experienced by broilers was examined under tropical conditions using Akure, Nigeria (7° 15’N, 5° 17’E), as a case study. One hundred and eight (108) of 4-weeks old broilers (Ross 308) were used for the study. The broilers were stocked at 6 broilers per cage in 18 cages in an open sided naturally ventilated poultry house and commercial feed (crude protein: 210g/kg; ME: 13 MJ/kg) and water were provided ad-libitum. The trial was conducted between 3rd and 22nd February 2003. February was chosen because it is usually the hottest month in the year in Akure. The air temperature, relative humidity and wind speed were measured inside and outside the poultry house for the period. A temperature humidity index (THI) chart for broiler was used to categorize the thermal heat stress regimes experienced by the broilers. Out of the five categories of thermal regimes on this chart only three (comfort, moderate heat stress and high heat stress) were characterized. The birds in the cages at the lowest level were comfortable for about 4% of the study period while those in the middle and topmost cages were comfortable for about 12 and 34%, respectively. Also the birds in the cages at the lowest level were only moderately stressed for about 64% of the study period while those in the middle and topmost cages were moderately stressed for about 60 and 43%, respectively. Birds in the cages at the lowest level were highly stressed for about 32% of the study period while those in the middle and topmost cages were highly stressed for about 28 and 23%, respectively. Panting and core body temperature were also observed to increase with increasing ambient temperature above 28 °C. These results showed the tropical conditions that are prevalent in Akure were not ideal to the birds for optimum comfort and performance. However, in the meantime, these data sets will be useful in growth models as well as the design of low cost environmental management systems for improved broiler productivity in Nigeria.

Keywords: Akure, broilers, heat stress, 3-tier cages, hot-humid
INTRODUCTION

Poultry production plays a major role in food security for the rapidly growing human population, particularly in developing countries. Broilers are particularly susceptible to heat stress because their metabolic heat production increases with growth rate while the capacity to dissipate heat does not (Teeter et al., 1996). The hot-humid climate in tropical countries is far from ideal for commercial farming of modern breeds of poultry. This often poses serious challenges to the growth of the poultry industry in Nigeria.

Heat stress interferes with the broiler’s comfort and reduces performance and production efficiency. The bottom line is that the full genetic potential of today’s genetically superior broiler is often not achieved leading to great economic losses and reduced profitability of broiler production in the tropics. The annual economic loss in the Americas and Asia due to heat stress is enormous (Swick, 1998; Donald et al., 2001). Similar losses if not more are likely for broiler production in Nigeria, but this appears not to have been quantified yet. Data on the level of heat stress experienced by broilers raised in this environment needed for crucial environmental management are also lacking. This paper therefore aims to bridge this knowledge gap by investigating the microclimate under typical grow-out conditions, determine the categories and frequencies of heat stress experienced by broilers under these conditions in Southwest, Nigeria. Also studied is the behavioural response of broilers to the different categories of heat stress.

MATERIALS AND METHODS

Site and Instrumentation

The study was carried out at the Livestock Unit of the Teaching and Research Farm of the Federal University of Technology, Akure (7° 25’N 5° 17’E), in an open sided naturally-ventilated broiler house. The broiler starters (Ross 308) were raised in three-tier cages at a stocking density of 6 broilers per cage; there were 18 cages in all with a total of 108 birds. The birds were 4 weeks old when the measurements started. Commercial feed (CP: 21 g/kg; ME: 13 MJ/kg) and water were provided ad-libitum.

Air temperature, relative humidity and wind speed were measured inside and outside the poultry house with a hand held non-ventilated psychrometer, digital temperature and humidity (RHT1) sensors and sensitive 3-cup rotor anemometers, all connected to a data logger (Squirrel, 1250 Series), manufactured by Delta-T Devices, UK and Grant Instruments, UK respectively. Core body temperature (rectal) was measured with clinical mercury-in-glass thermometer as presented in Plates 1 - 3.

Calculations

1. Saturation vapor pressure, e_s and the vapor pressure, e were calculated in kPa with the dry and wet bulb temperature measurements from the psychrometer. Finally, the relative humidity, RH, is calculated in percent, (Jensen et al., 1990).

\[ RH = 100 \left( \frac{e}{e_s} \right) \]  

Where e is vapour pressure and e_s is saturated vapour pressure.

This was also obtained from psychrometric tables in order to compare manual and automated measurements. The categories of heat stress experienced by the broilers under the grow-out conditions was then determined from the measurements using a temperature humidity index chart (Swick, 1998) that shows the effect of air temperature and humidity on broiler heat stress, see Figure 1.
Plate 1: The hand held non-ventilated psychrometer in use at the level of the middle cage

Plate 2: Air Temperature and Relative Humidity measurement set-up outside the broiler house
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Plate 3: Air Temperature and Relative Humidity measurement set-up inside the broiler house
RESULT AND DISCUSSION

Relative humidity (Figure 2) was observed to be at or near 90%-100%, inside and outside the broiler house at night when the air temperatures are the lowest, in the low to mid twenties (22-25 ºC). Also, as the sun rises and temperatures increase to highs in the mid thirties (32-35 ºC), about a 10ºC increase, the relative humidity is approximately cut in half and drops to between 40 to 50%. Generally as temperature increases, the relative humidity decreases.

There was no observed significant difference in air temperature inside and outside the broiler house during the hottest part of the day, but the outside temperature was observed to be about 1-4 ºC cooler than the inside of the poultry house at night. Also, the temperature at the level of the middle cage (T2) was consistently higher than at the level of the highest (T3) and lowest (T1) cages during the night by about 0.5 ºC and 1.5 ºC, respectively, due to the heat produced by the birds below and above them (Figure 3). Observation also showed that there was about a 5 % and 10% difference in inside and outside humidity values during the daytime and nighttime, respectively. The “crossover” of temperature and relatively humidity was observed to occur at about 11 a.m. and 9 p.m during hot weather, when it gets hot earlier in the morning and it stays hot later at night, this “crossover” of temperature and relative humidity may occur a little earlier in the morning and later at night (Figure 3).
Figure 5: Temperature-humidity Relationship inside and outside the broiler house, Akure (Feb., 2003).
Figure 3: Half-hourly Temperature and Relative Humidity Measurements inside and outside an open sided broiler house in Akure (9th – 10th Feb, 2003).

Figure 4 showed the variation of random core body temperature with ambient air temperature in the poultry house. The figure suggests that the birds were acclimatized to high temperatures as core body temperatures were maintained at 42.0°C; between 29.0° and 34.0°C. Core body temperature were observed to rise above 42.0°C when ambient temperatures exceed 34.0°C. This suggests that for these birds, the onset of heat stress might be 29.0 °C rather than 25 - 27.0 °C generally quoted in the literature for un-acclimatized birds (Mitchell and Kettlewell, 1998). The optimum thermo-neutral temperature zone for comfort for fully feathered broilers (> 4 weeks old) lies around 22 - 25 °C, however, unless the temperature they experience is within one or two degrees of this optimum, they will need to expend feed energy to maintain their comfort, rather than for growth and weight gain (Donald et al., 1999).

Figure 5 showed the three heat stress regimes (comfort, moderate and high) experienced by the broilers and the frequency of the times they were experienced during the grow-out conditions under study. The birds in the cages at the lowest level were only comfortable for about 4 % of the study period, while those in the middle and topmost cages were only comfortable for about 12 and 34 % of the study period respectively.
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Figure 4: Variation of core body temperature with ambient air temperature during the period of study.
Observation also show that the birds in the cages at the lowest level were only moderately stressed for about 64 % of the study period, while those in the middle and topmost cages were moderately stressed for about 60 and 43 % of the study period respectively. Birds in the cages at the lowest level were observed to be highly stressed for about 32 % of the study period, while those in the middle and topmost cages were highly stressed for about 28 and 23 % of the study period respectively. Birds were observed to exhibit various behavioural patterns under the comfort, moderate and high heat stress categories. For the comfort categories birds were observed to be comfortable and are eating and drinking continuously (Plate 4).

For the moderate heat stress category, all the birds were observed to be panting, stay apart, hold their feathers together, droop or lift wings, drink more water and eat less feed, see Plates 5a and b. For the high heat stress category, all the birds were observed to be panting intensely, stop feeding entirely, back feed trough and dip their wattles in the water troughs also normal pink areas of their skin were observed to turn dark red, see Plates 6 a and b. This is because under this condition more of the blood circulation is shifted to extremities and the surface of the body to dissipate heat (Donald, 1999). Body temperature was observed to be between 42.5-43 °C under this heat stress category.

Figure 5: Categories of heat stress experienced by broilers during the study.
Plate 4: The comfort THI stress category- birds are comfortable and are eating well.
Plate 5a: The moderate THI stress category- birds are panting, sit, stay apart and generally may not eat to reduce internal heat build up and their body temperature rising too high.

Plate 5b: The moderate THI stress category- birds are panting, sit, stay apart and generally may not eat to reduce internal heat build up and their body temperature rising too high.
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Plate 6a: The high THI stress category- birds are panting intensely, feeding stops totally, sit, back feed trough and dip wattles in water to cool themselves and bring down their already too high body temperature

Plate 6b: The high THI stress category- birds are panting intensely, feeding stops totally, sit, back feed trough, dip wattles in water to cool them and bring down their already too high body temperature
CONCLUSION

This study showed that the conditions under which broilers are raised in naturally ventilated open-sided broiler houses in the tropics are far from adequate for maximum production efficiency as performance could be adversely affected by heat stress. The actual level of loss to the farmer still needs to be quantified as hot and humid weather slows this natural process and reduces performance and profit. All the experimental birds suffered heat stress with birds in the lowest cage suffering more and consequently, are less comfortable throughout the grow-out period. The design of this particular poultry house could be responsible for the observed patterns, as the birds in the cages at the highest level were exposed to more fresh air exchange and higher wind speed compared to the birds at the lowest level. Broilers have two major ways to cool themselves: panting (evaporative heat loss) and air movement (sensible heat loss). To maintain body temperature by sensible heat loss, the birds do not need to drastically alter their normal behavioural patterns, feed intake or metabolism. The purpose of poultry house design and ventilation will therefore be to maintain a high enough air velocity or a low enough temperature in the house that the birds can maintain body temperature by sensible heat loss. It is important to know that broilers have a strict priority system in the process of converting feed to meat, dictating that feed nutrients always go first to body maintenance functions, such as maintaining internal body temperature. This implies that, the feed nutrients that can be used for growth and weight gain are those available after the broiler’s survival needs have been met. When birds are stressed, they are unable to maximize weight gain, using more feed nutrients for body maintenance and less for growth. The reverse is the case when they are not stressed.

RECOMMENDATION

Any management technique that increases nutrient intake during heat stress will minimize the drop in production efficiency. Nutrient consumption can be increased by increasing nutrient density, taking advantage of natural increases in feed consumption at certain times of the day, and keeping birds as cool as possible. Birds can be kept cool by providing adequate ventilation (use of circulation fans, tunnel ventilation) and evaporative cooling systems. The provision of ample cool water and prevention of solar radiation into the poultry house and water system will also be highly beneficial. Use of insulation and shade are cost effective and will improve profits. The use of high chick quality, balanced nutrition, and lower stocking density will also be extremely useful. A combination of sound environmental and nutrition management will greatly improve production efficiency and yield maximum profitability.

REFERENCES


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