Effect of Ambient Temperature on the Performance of Shaver Brown Hens in Hot Humid Environment

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Authors’ contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

ABSTRACT

The effect of temperature on the performance of Shaver brown hens in the hot humid environment was investigated using seventy-five Shaver brown hens in their 14th week of lay. Each hen was housed in individual battery cage and fed daily with 125 g of commercial layers mash containing 16.5% crude protein, 2650 kcal/kg metabolizable energy, 4% crude fat, 6.5% crude fibre, 3.6% calcium and 0.4% phosphorus for 10 weeks. Water was supplied ad libitum to the birds. Eggs were collected daily and recorded for each hen. Data were collected on average daily feed intake (ADFI), egg weight, eggshell weight, egg shell thickness, egg shape index, albumin height, yolk height, albumin index, yolk index, haugh unit and hen day egg production. Results showed that ADFI, hen day egg production, egg shape index, albumin height, yolk height, yolk index and Haugh units were significantly (P < 0.05) decreased with increase in ambient temperature. However, high ambient temperature did not have significant (P > 0.05) effect on egg weight, eggshell thickness and albumin index. Based on the results obtained in the study, it was concluded that ambient temperature had an effect on the performance of Shaver brown hens in the humid tropics.

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1. INTRODUCTION

The ultimate objective of the poultry farmer is the realization of profit, and in order to do this, he must understand the interactions between body conformation, body function and environment. In the tropical context, environment (mainly temperature and humidity) plays a very important role as it imposes extra stress in the ability of the chicken to grow and function optimally. Although all livestock are subject to environmental stress in the tropics, humid environment is very suitable for poultry production because poultry appears to be less susceptible than mammals. One reason may be that with higher body temperature than mammals, birds spend less production energy than other livestock in homeostatic regulations (adjustments). Under suitable tropical housing and management practices, poultry performance in the tropics has in many instances compared favourably with the performance standards of the same breeds reared in temperate environments. In acclimatizing to hot climate, animals normally make physiological adjustments [1,2,3,4]. As the seasons change, two major kinds of changes occur in the environments: changes in temperature and changes in the length of daylight. For many years, researchers have been investigating the effect of high environmental temperature and relative humidity on the performance of different poultry species, including turkeys and have found that high environmental temperatures have deleterious effects on performance of laying hens [5,6,7,8]. In laying hens, heat stress depresses body weight, egg production, egg weight and shell quality, and is generally accompanied by suppression of feed intake which could be the cause of decline in production [9,10]. Heat stress in poultry is prompted by combinations of environmental temperature and humidity that prevent birds' thermoregulatory processes from effectively dissipating the heat produced during metabolism. Poultry birds are said to be thermally stressed when ambient temperature exceeds body temperature such that peripheral physiologic responses of the bird can no longer match the external changes. During heat stress, the environmental parameters of ambient temperature (AT) and relative humidity (RH) in general and temperature humidity index (THI) in particular, have been reported as invaluable tool in the presumptive diagnosis of the animal state of health, and is also relevant in evaluating the adaptability of the animal [4,11]. Altan et al. [12] reported that high ambient temperature and relative humidity result in increased heat stress and are responsible for the increase in rectal/body temperature. Chronic heat stress results in behavioural changes, depressed feed intake [13,14] and a wide range of metabolic activities [15], including elevation of body temperature, electrolyte, acid-base and hormonal imbalances [16]; and tissue damage [17]. Egg production and shell quality in laying hens will be depressed [18]. The ideal temperature (conventionally referred to as the zone of thermo neutrality) under which performance of laying hens is not adversely affected by temperature has been identified as 18 - 22°C [16,19]. Temperatures outside the critical limits of the thermoneutral zone such as those prevailing in most humid tropical regions of the world have been reported to constitute heat stress [16,20,21,22,23,24]. Egg quality and production as a whole are affected by temperature which is manifested by the effect it has on the physiology and metabolism of the hen. During hot weather, there is a reduction of carbonate ions in the blood which lowers the buffering capacity and may lead to poor buffering of hydrogen ions produced during shell formation. This explains why there is a low egg production in hot weather and also why eggs laid during hot weather have thin shells. Against this backdrop, this study was therefore conducted to investigate the effect of ambient temperature on the performance of Shaver brown hens in hot humid environment.

2. MATERIALS AND METHODS

2.1 Location and duration of Study

The study was conducted at the Poultry Unit of the Department of Animal Science Teaching and Research Farm, University of Nigeria, Nsukka. Nsukka lies in the derived savannah region, and is located on longitude 6° 25’ N and latitude 7° 24’ E [25] at an altitude of 430 m above sea level [26]. The climatic data taken during the period of the experiment showed the study area had the natural day-length of 13 to 14 hours; mean maximum weekly indoor and outdoor temperatures of 27.9°C to 29.2°C and 26.8°C to 30.5°C, respectively; mean minimum weekly indoor and outdoor temperatures of 20.5°C to 22.3°C and 20.0°C to 23.60°C respectively, relative humidity of 73.1% to 76.6% and mean...
total monthly rainfall of 781.33 mm [26,27,28]. The study which lasted for 10 weeks was conducted in a late wet season (July – September).

2.2 Experimental Birds and Management

The experiment was carried out in accordance with the provisions of the Ethical Committee on the use of animals and humans for biomedical research of the University of Nigeria, Nsukka. Seventy-five Shaver brown hens in their 14th week of lay were used for the study. The hens were selected from a flock of laying hens in the farm. Each hen was housed in individual battery cage as observations were made on the hens individually. The hens were housed in an open-sided building with a block wall of 90 cm high and wire netting to the roof. Feeding was done using v-shaped, long and detachable feeders while provision of water was done using U-shaped water containers. Hens were fed commercial layers mash containing 16.5% crude protein, 2650 kcal/kg of metabolizable energy, 4% crude fat, 6.5% crude fibre, 3.6% calcium and 0.4% phosphorus. Each hen received about 125 g of layers’ mash daily and ad libitum supply of water.

The water supplied to the birds was medicated with an anti-stress (Vitalyte) for a period of one week at the start of the experiment and occasionally during the experimental period. Eggs were collected daily and recorded for each hen. As a general flock prophylactic management strategy, routine vaccinations, medications and other health operations were carried out as and when due. Wood shavings were spread under the battery cages to absorb moisture and ease regular removal of poultry droppings from the laying house, usually weekly. The surroundings of the experimental birds were kept as tidy as possible. Dead birds were promptly removed and taken to the Veterinary Teaching Hospital, University of Nigeria, Nsukka for autopsy as the need arose. No supplemental light was provided during the period of the study.

2.3 Parameters Measured

The parameters measured included as follows:

Egg Weight (g): Egg weight was taken for every egg collected for the hens in relation to oviposition time weighing was done for all eggs within one hour of collection. Electronic balance (D & G sensitive scale) was used and the measurement expressed in grammes.

Egg Quality: Sixteen (16) eggs were selected at random weekly for egg quality analysis. The indices determined were as follows:

Egg Shell Weight (g): Each egg was carefully broken and dried after which the egg was weighed using a weighing balance.

Egg Shell Thickness (mm): This was determined by pulling off the shell immediately the egg was broken and the shell was air-dried for a day (24 hours) after which the eggshell thickness was determined with the help of a micrometer screw guage.

Egg Shape Index: The egg shape index was calculated as the proportion of egg length to diameter.

Albumin Height and Diameter (mm/cm): The eggs after weighing were broken into a flat bottom glass (beaker) positioned on a flat surface. The albumin height was measured using a tripod micrometer. Albumin diameter was taken as the maximum cross-sectional diameter of the albumin using a pair of calipers and read on a ruler calibrated in millimeter.

Yolk Height and Diameter (mm/cm): The eggs after weighing were broken into a flat bottom glass (beaker) positioned on a flat surface. The yolk height was measured using a tripod micrometer. Yolk diameter was taken as the maximum cross-sectional diameter of the yolk using a pair of calipers and read on a ruler calibrated in millimeter.

Albumin Index: The albumin index was calculated as the proportion of yolk height to diameter.

Yolk Index: The yolk index was calculated as the proportion of yolk height to diameter.

Haugh Unit: This was calculated from the values obtained from the albumin height and egg weight by using the formula: Haugh’s unit = 100 log (H + 7.57 - 1.7 W^{0.37}) as described by [29].

Average Daily Feed Intake (g): 

\[ \text{Feed Offered (g)} - \text{Feed Refusals (g)} \]
\[ \text{Number of Hens} \]

Percentage Egg Production: Percentage egg production was calculated using the formula as shown below:
Hen housed egg production (HHEP): This was obtained by dividing the total number of eggs by each strain of hen by the number of hens housed in the laying cages. This does not take mortality into account.

Hen housed egg production (HHEP) =

\[ \text{No of eggs laid} \] \\
\[ \text{No of hens housed} \]

Hen day egg production (HDEP): It was obtained by dividing the total number of eggs by the number of hen days.

Hen day egg production (HDEP) =

\[ \frac{\text{No of eggs laid}}{\text{No of hen days}} \]

2.4 Statistical Analysis

Descriptive statistics such as means and standard error of the means, percentages for some of the parameters were calculated. Other data collected were subjected to analysis of variance (ANOVA) for completely randomized design (CRD) using a Stat Graphic Computer Package Model. Significantly different means were separated using Duncan’s New Multiple Range Test option in SPSS [30].

3. RESULTS AND DISCUSSION

3.1 Mean Weekly Environmental Temperatures and Relative Humidity

The mean values of weekly environmental temperatures and relative humidity recorded during the period of study are presented in Fig. 1.

3.2 Environmental Temperatures and Relative Humidity of the Study Area

The climatic data taken during the period of the experiment showed the study area had the mean maximum weekly indoor and outdoor temperatures of 27.9°C to 29.2°C and 26.8°C to 30.5°C respectively; mean minimum weekly indoor and outdoor temperatures of 20.5 °C to 22.3°C and 20.0°C and 23.60°C respectively and relative humidity of 73.1% to 76.6%. The climatic data (Fig. 1) of Nsukka, the study location during the study period was similar to the data presented by [31] which showed that the monthly minimum temperature ranged from 18.00°C to 24.00°C, maximum temperatures from 32.25°C to 38.00°C and relative humidity from 46.90 to 81.40% in the humid tropics. It is also consistent with the findings of [13,32] that in the tropics, egg production can be efficient at ambient temperatures as high as 32°C but not when temperatures rises above 35°C for sustained periods. The relative humidity appeared to have no effect on egg laying performance at ambient temperatures below 27°C, although it might have affected performance at higher temperatures. In practice, layers in the tropics would normally be managed at a somewhat lower average temperature than 32°C.

3.3 Effect of Temperature on Performance of Shaver Brown Hens

The effect of temperature on the performance of Shaver brown hens is presented in Table 1.

3.4 Average Daily Feed Intake and Hen Day Egg Production

The average daily feed intake (ADFI) was reduced (P < 0.05) in proportion to the severity of heat stress exposure. The ADFI decreased significantly (P < 0.05) from 62.85 ± 1.83 to 55.13 ± 0.68 as the temperature increased from 24.50°C to 25.70°C.

As shown in Table 1, there was significant decrease (P < 0.05) in average daily feed intake (ADFI) with increasing temperatures. The observed significant decrease in average daily feed intake (ADFI) with increasing temperatures is consistent with the findings of [33,34,35,36,37] which showed that there was reduced feed intake under varying degrees of heat exposure. Similar results have been reported by [38,39]. Their reports showed that the primary effect of high-temperature stress on laying performance was a marked reduction in feed consumption. The decrease in ADFI could be due to reduced appetite associated with reduced performance at high temperatures. Animals eat more at low temperatures than at high temperatures and stop eating to prevent hyperthermia [40,41,42]. The result obtained in the present study however, is at variance with the findings of [43] that acute heat stress had no effect on feed intake in laying hens.
Table 1. Effect of temperature on performance of Shaver brown hens

<table>
<thead>
<tr>
<th>Parameters</th>
<th>1 (24.50 °C)</th>
<th>2 (24.70 °C)</th>
<th>3 (24.90 °C)</th>
<th>4 (25.00 °C)</th>
<th>5 (25.20 °C)</th>
<th>6 (25.70 °C)</th>
<th>Overall mean ± SE</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hen day egg production (g)</td>
<td>56.43±1.63</td>
<td>50.57±1.53</td>
<td>48.71±2.44</td>
<td>47.71±1.54</td>
<td>47.43±1.69</td>
<td>46.57±2.06</td>
<td>49.82±0.85</td>
<td>*</td>
</tr>
<tr>
<td>Average daily feed intake (g)</td>
<td>62.85±0.70</td>
<td>60.99±0.50</td>
<td>58.98±0.68</td>
<td>60.89±0.77</td>
<td>58.75±0.96</td>
<td>55.13±0.68</td>
<td>59.94±0.40</td>
<td>*</td>
</tr>
<tr>
<td>Egg weight (g)</td>
<td>66.16±1.83</td>
<td>64.40±0.65</td>
<td>64.73±0.64</td>
<td>63.07±0.80</td>
<td>62.98±1.86</td>
<td>64.26±1.56</td>
<td>64.30±0.46</td>
<td>NS</td>
</tr>
<tr>
<td>Egg shell weight (g)</td>
<td>8.10±0.01</td>
<td>8.07±0.004</td>
<td>8.06±0.01</td>
<td>8.03±0.01</td>
<td>8.05±0.01</td>
<td>8.07±0.05</td>
<td>8.06±0.01</td>
<td>*</td>
</tr>
<tr>
<td>Egg shell thickness (mm)</td>
<td>0.24±0.004</td>
<td>0.23±0.004</td>
<td>0.24±0.01</td>
<td>0.24±0.02</td>
<td>0.22±0.01</td>
<td>0.24±0.07</td>
<td>0.23±0.03</td>
<td>NS</td>
</tr>
<tr>
<td>Egg shape index</td>
<td>1.45±0.01</td>
<td>1.46±0.01</td>
<td>1.45±0.01</td>
<td>1.43±0.11</td>
<td>1.42±0.01</td>
<td>1.43±0.01</td>
<td>1.44±0.003</td>
<td>*</td>
</tr>
<tr>
<td>Albumin height (mm)</td>
<td>7.71±0.06</td>
<td>7.28±0.04</td>
<td>7.09±0.06</td>
<td>6.99±0.10</td>
<td>6.85±0.07</td>
<td>6.75±0.12</td>
<td>7.16±0.05</td>
<td>*</td>
</tr>
<tr>
<td>Albumin index</td>
<td>0.11±0.00</td>
<td>0.11±0.00</td>
<td>0.11±0.00</td>
<td>0.11±0.00</td>
<td>0.11±0.00</td>
<td>0.11±0.00</td>
<td>0.11±0.00</td>
<td>NS</td>
</tr>
<tr>
<td>Yolk height (mm)</td>
<td>18.91±0.01</td>
<td>18.68±0.04</td>
<td>18.68±0.03</td>
<td>18.60±0.01</td>
<td>18.33±0.05</td>
<td>18.41±0.03</td>
<td>18.62±0.03</td>
<td>*</td>
</tr>
<tr>
<td>Yolk index</td>
<td>0.60±0.001</td>
<td>0.61±0.002</td>
<td>0.62±0.004</td>
<td>0.63±0.003</td>
<td>0.62±0.003</td>
<td>0.62±0.001</td>
<td>0.61±0.002</td>
<td>*</td>
</tr>
<tr>
<td>Haugh unit</td>
<td>86.46±0.15</td>
<td>83.75±0.24</td>
<td>82.72±0.05</td>
<td>82.55±0.10</td>
<td>81.18±0.11</td>
<td>81.17±0.37</td>
<td>83.17±0.24</td>
<td>*</td>
</tr>
</tbody>
</table>

* Means values in a row with different superscripts are significantly different (P<0.05)
* = (P<0.05); NS = Not Significant
The hen day egg production (HDEP) was inversely related to high temperature. As the temperature increased linearly from 24.50°C to 25.70°C, the HDEP significantly decreased (P < 0.05). As shown in Table 1, the significant (P < 0.05) decrease observed in hen day egg production corroborates the findings of [8,37] that hen day egg production in white leghorn hens decreased when they were exposed to high environmental temperature. The decrease in egg production could be due to a decrease in feed consumption, thereby reducing the availability of nutrients for egg production. However, the result obtained in the present study is at variance with the findings of [44]. Mardsen et al. [44] reported increased egg production rate by 1.1% on pullets exposed to temperatures of 18°C - 24°C.

3.5 Egg Weight

Exposure of the Shaver brown hens to high temperatures did not have a significant effect on egg weight (P > 0.05). Mean egg weights ranged from 62.98 g ± 1.86 to 66.16 g ± 1.83 within a temperature range of 24.50°C to 25.70°C. Increasing temperature had no significant effect (P > 0.05) on egg weight. Similar observations were made by [37,45] who found out that heat stress did not significantly affect egg weights.

3.6 Egg Shell Weight, Egg Shell Thickness and Egg Shape Index

The egg shell weight was significantly (P < 0.05) influenced by temperature. The egg shell weight values at 24.50°C, 24.70°C, 24.90°C, 25.20°C and 25.70°C were comparable. The egg shell weight value observed at 24.50°C was higher than the value observed at 25.00°C. The egg shell weight significantly decreased (P < 0.05) with increasing temperature. This result supports earlier reports by [9,18,39,46,47] who observed decreased egg shell weight under high temperature. The reason could be due to decrease in plasma protein concentration plasma calcium concentration both of which are required for egg shell formation [9,48]. It had been shown by [49] that calcium uptake and usage by duodenal epithelial cells are decreased by exposure to high environmental temperature. It has also been reported that plasma calcium level was significantly decreased in laying hens [9,50] and in turkeys [50] when birds were exposed to high temperatures. Also, high temperature could prevent the reproductive tract of laying hens from probably getting enough nutrient supply as a result of low blood supply and therefore reducing nutrients reaching the reproductive tract for normal egg formation [51]. This result, however,
contrasts the findings of [45] who noted that heat exposure did not significantly affect egg shell weight. The small temperature range the hens were exposed to during the experiment and the genetic makeup of individual strains could have caused the observed difference. Egg shell thickness was not significantly (P > 0.05) affected by temperature. Increasing temperature did not affect egg shell thickness significantly (P > 0.05). This is in line with the findings of [37] that high temperature did not affect shell thickness significantly. The egg shape index was significantly (P < 0.05) influenced by temperature. As the temperature increased beyond 25°C, the egg shape index was reduced significantly (P < 0.05) from 1.45 ± 0.01 (25.40°C) to 1.42 ± 0.01 (25.20°C).

3.7 Albumin Height, Albumin Index, Yolk Height and Yolk Index

The albumin height was reduced significantly (P < 0.05) as the temperature increased beyond 24.50°C. The highest value was 7.71 ± 0.06 mm at 24.50°C. The albumin height (7.28 ± 0.04 mm) at 24.70°C was significantly (P < 0.05) higher than the values 7.09 ± 0.06 mm, 6.99 ± 0.10 mm, 6.85 ± 0.07 mm and 6.75 ± 0.12 mm obtained at 24.90°C, 25.00°C, 25.20°C, 25.70°C, respectively. The effect of temperature on albumin index was not significant (P > 0.05). The effect of temperature on albumin height was significant (P < 0.05). This supports the findings of [52] that temperature affects albumin height. Yolk height was significantly (P < 0.05) decreased as the temperature increased beyond 24.50°C. The highest value (18.91 ± 0.01 mm) was observed at 24.50°C. The values (18.68 ± 0.04 mm, 18.68 ± 0.03 mm and 18.60 ± 0.01 mm) observed at 24.70°C, 24.90°C and 25.00°C, respectively were comparable (P > 0.05) and were higher (P < 0.05) than the values (18.33 ± 0.05 mm and 18.41 ± 0.03 mm) observed at 25.20°C and 25.70°C, respectively. The effect of temperature on yolk index was significant (P < 0.05). The yolk index increased as the temperature increased significantly (P < 0.05) from 24.50°C to 25.00°C and decreased (P < 0.05) as the temperature increased beyond 25.00°C. This corroborates the findings of [52] that temperature affects yolk index.

3.8 Haugh Units

The Haugh units significantly decreased (P < 0.05) from 86.46 g ± 0.15 to 81.17 g ± 0.37 as the temperature increased. The birds had significantly higher (P < 0.05) Haugh units at temperature of 24.50°C and the lowest at 25.70°C. The Haugh unit was significantly (P < 0.05) high at low temperature ranges and it decreased significantly (P < 0.05) with increasing temperature. This supports the findings of [34] that Haugh units of eggs from heat stressed birds were reduced when exposed to heat. It could be that reduced egg production due to heat stress had a negative impact on the egg quality [53]. However, this disagrees with [33] who reported high Haugh units in eggs of birds exposed to high temperatures.

4. CONCLUSION

The results obtained in the present study show that increase in ambient temperature had an adverse effect on the performance of Shaver brown hens in the humid tropics.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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