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Assessing Thermal Comfort of Broiler Chicks

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Abstract: Proper management of the thermal environment during brooding is essential to performance in broilers. Brooding programs used in the broiler industry are prescriptive, but little information exists about thermal comfort in chicks. Identifying thermal conditions that chicks prefer would allow for better management of the thermal environment during brooding. The objective of this study was to determine thermal conditions that are preferred by broiler chicks. Thirty broiler chicks at seven days of age were fitted with a harness holding a miniature temperature data logger; air temperature directly above the chicks' backs was measured every 3 minutes for 7 days from 8 to 14 days of age. Air temperature in the room was measured in 25 locations on the same interval as the harnesses. The room was held at 32.2°C for the first week and reduced to 29.4°C the second week. Air temperature, as measured by the bird harnesses, was significantly higher than measured in the room. Overall least squares means for harness and room temperatures were 33.0 and 29.2°C, respectively and were significantly different ($P < 0.0001$). The estimated difference between harness and room temperature was 3.8°C with a standard error of 0.06°C; the least significant difference was calculated as 0.15°C.

Key words: Brooding, thermal environment, broiler industry

Introduction

Proper management of the thermal environment during brooding is essential to performance in broilers. Brooding programs used in the broiler industry are prescriptive, but little information exists about thermal comfort in chicks.

The effects of brooding temperature on chick performance are well documented. Generally, gain is not affected at air temperatures ranging from 26.7 to 35°C (Huston, 1965; Renwick *et al.,* 1985; Harris *et al.,* 1975). Temperatures exceeding the upper critical temperature have been shown to decrease performance (Van der Hel *et al.,* 1992). May and Lott (2000) found that feed conversion increases with decreasing air temperature. Mortality has also been shown to increase with decreasing air temperature (Huston, 1965; Renwick *et al.,* 1985; Deaton *et al.,* 1996; Bruzual *et al.,* 2000).

Differences between sexes have also been observed. Harris *et al.* (1975) studied the effects of brooding temperatures from 26.7°C to 35°C and found that optimal temperatures for three week body weight gain were 30.8°C and 31.7°C for males and females, respectively. Feed efficiency was improved for brooding temperatures of 30.8°C and 35°C. However, no differences in eight week weights were observed.

Deaton *et al.* (1996) evaluated three different brooding temperature ranges and found that a low temperature brooding program (26.7, 24.4, and 21.1°C for weeks 1 through 3, respectively) showed no significant difference in performance at 6 weeks, but was not recommended due to problems with piling and smothering. Deaton (1995) recommended the following brooding temperatures: 29.4°C during week 1, 26.7°C during week 2 and 23.9°C during week 3. Charles (1986) concluded that behavior is the best indicator of chicks' thermal comfort. Although temperature may vary depending on management, it was suggested that temperature should be set at 31°C at chick placement and then decrease to 17 to 21°C at three weeks of age (Charles, 1986).

Studies to determine thermal preferences and assessment of thermal comfort of chicks have been documented by Baxter *et al.* (1970) and Aslam and Wathes (1991). Baxter *et al.* (1970) used black globe temperature as an indicator of thermal comfort under infrared brooders and found that on average, chicks showed a preference for a given temperature, with the standard errors for weekly means of less than 1.4°C. They demonstrated that chicks preferred a temperature of 25.7°C during the first week of life; however preferred temperature was increased (18%) in birds undergoing immunologic stress (Baxter *et al.,* 1970). Aslam and Wathes (1991) observed chicks moving between cooler and warmer zones around a radiant brooder. Huddling patterns differed between room air temperatures of 21 and 27°C. Neither of these studies were able to account for the micro-environment created at chick level, especially within groups.

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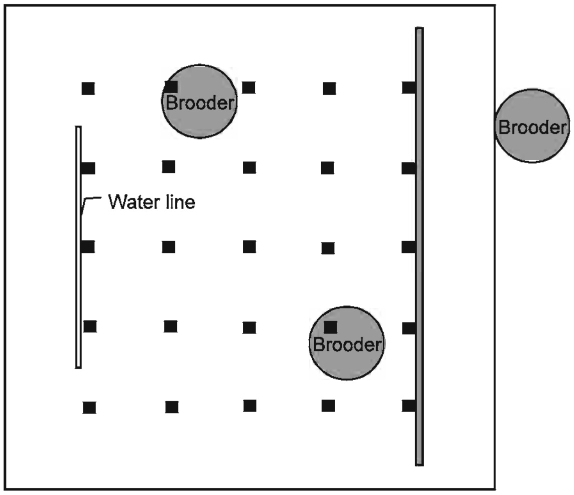

Fig. 1: Schematic of pen within house. Air temperature measurement locations are represented by (■). Brooders were elevated 91 cm from the floor and water line height was adjusted according to manufacturer's recommendations.

Identifying thermal conditions that chicks prefer would allow for better management of the thermal environment during brooding. To date, there has been no attempt to characterize the micro-environment surrounding the chick, especially in the context of huddling behavior for thermoregulation. The objectives of this study were to: 1) develop a method to continuously measure air temperature surrounding a young chick and 2) determine air temperatures preferred by broiler chicks by directly monitoring air temperature near the chick during the second week of production.

Materials and Methods

Birds and husbandry: A total of 400 Ross x Ross 708 chicks was obtained from a commercial hatchery and placed at 10.8 bird•m^{-2} (1 bird•ft^{-2}) in a 6.1 m x 6.1 m (20 ft x 20 ft) pen inside a 15.2 m x 10.9 m (50 ft x 36 ft) curtain sided house. The house was equipped with six 8.8 kW radiant brooders (GB-UV, Shenandoah Mfg. Co., Inc., Harrisonburg, VA) for supplemental heating; a schematic and photo of the pen area are shown in Fig. 1 and 2 respectively. The pen was equipped with tube feeders and nipple drinkers; feed and water were available ad libitum. In addition, feeder trays were used to ensure adequate availability to feed from 1 to 7 days of age. Air temperature set points for Week 1 and Week 2 were 32.2°C (90°F) and 29.4°C (85°F), respectively. Light intensity was held constant at 26.9 lux (2.5 fc) for both Weeks 1 and 2; lighting was continuous for Week 1 and changed to a 19L:5D photoperiod for Week 2. This study was approved by the Animal Care and Use Committee at the USDA-ARS Mississippi State location.

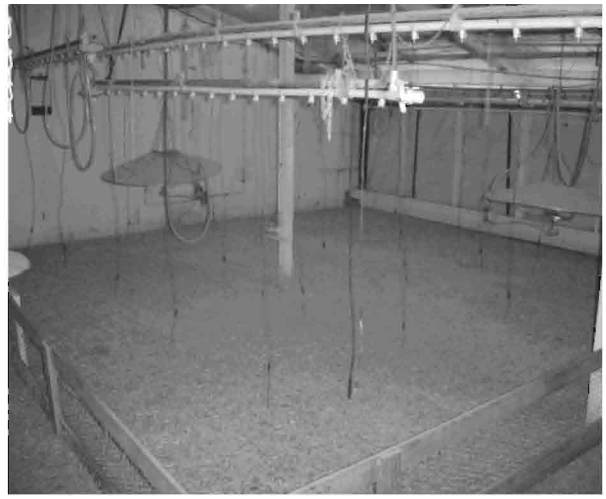

Fig. 2: Photograph of pen area. Thermocouples are suspended from the ceiling and spaced on 1 m intervals in a 5 x 5 grid.

Data acquisition: A total of thirty birds were fitted with harnesses for data collection. Harness temperature measurements were recorded using small data loggers with integral temperature sensors (DS1922L, Maxim Integrated Products, Sunnyvale, Cal.). Accuracy and resolution of the data loggers were specified by the manufacturer as 0.5°C and 0.0625°C in high resolution mode, respectively. Data loggers were calibrated in a water bath against a NIST-traceable RTD thermometer (DP97, Omega Engineering, Stamford, Conn.). In high-resolution mode, the data loggers can store 4096 measurements. On a 3 min measurement interval, the loggers can store data for up to 8.3 days before a download is necessary. A third-party software package (micro-T, NexSens, Beavercreek, Ohio) was used to interface with the data loggers for configuration and data retrieval; the software enabled synchronization of logging start times and measurement intervals.

Air temperature in the pen was measured with 25 type-T thermocouples spaced on 1 m intervals in a 5 × 5 grid and suspended 7.6 cm from the floor (Fig. 2). Thermocouples were routed through a multiplexer (AM16/32, Campbell Scientific, Logan, Utah) and recorded with a data logger (CR1000, Campbell Scientific, Logan, Utah) every 3 min. The harness and house data loggers were managed with the same notebook PC to maintain coordinated time stamps for all data.

Harness construction: A total of 30 harnesses (Fig. 3) were constructed to hold the data logger on the birds' backs; total weight as constructed was 7 g. The data loggers were mounted to a commercially available wall-mount bracket (DS9093S, Dallas Semiconductor, Sunnyvale, Cal.) and secured with a retaining washer

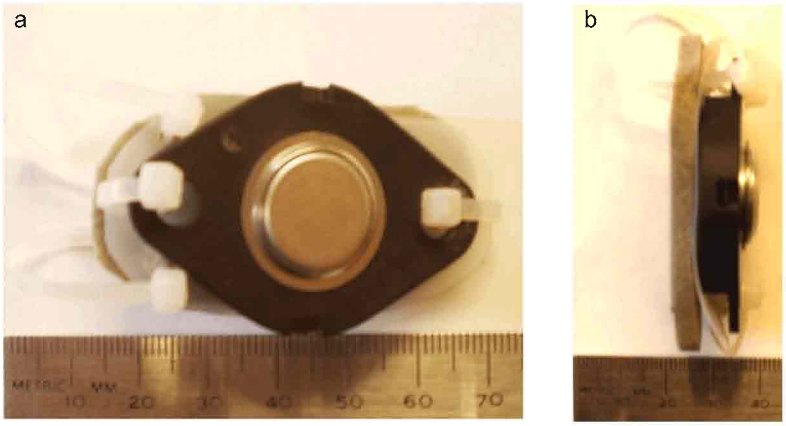

Fig. 3: Harness used to attach data logger to chick; top (a) and side (b) views.

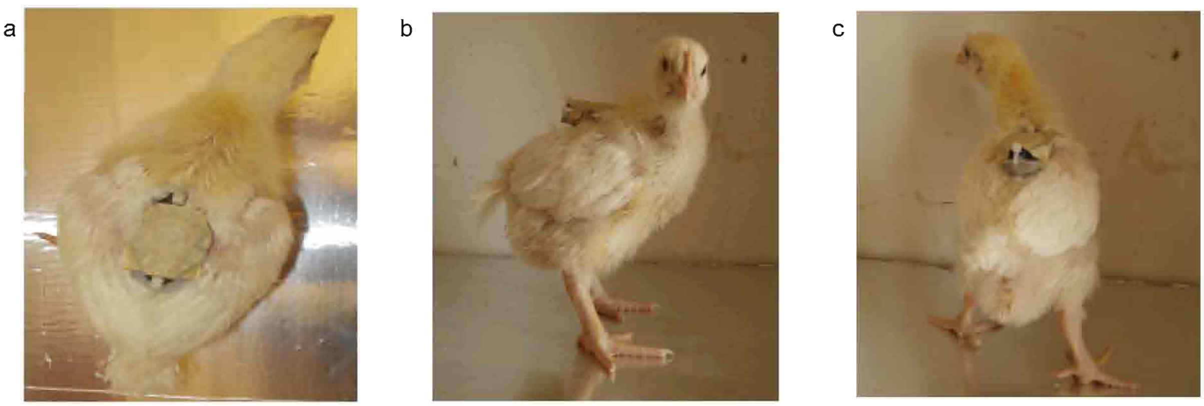

Fig. 4: Side (a), top (b) and rear (c) view of data logger harness on chick.

(DS9093RA, Dallas Semiconductor, Sunnyvale, Cal.); the brackets were attached to a thin sheet of polyethylene with wire ties. Closed-cell insulation tape (25.4 mm wide x 4 mm thickness) with adhesive backing was affixed to the polyethylene sheet. Two holes were punched through the polyethylene and insulation for attachment of mounting straps. Plastic wire ties were used as straps and cushioned with common masking tape. The harnesses were attached to the birds with a plastic wire-tie around the base of each wing (Fig. 4).

Statistical analysis: House temperatures and bird harness temperatures were compared using a mixed model (SAS v8.01, SAS Institute, Cary, N.C.). Days and measurement type (house or bird) were considered main (blocking) effects and their interaction, day*measurement type, was considered a random effect. Sources of sub-sampling error included observations within a day and multiple devices at each observation and were included in the residual error term. Means were separated using Fisher's LSD and considered significantly different at P $\leq$ 0.05.

Histogram analysis was used to determine the relative frequency of temperature observations during the study. The number of harness observations (30) is not equal to the number of house observations (25) and is presented as relative frequency rather than total number of observations; percentage relative frequency was calculated as:

$$f = \frac{n_T}{\sum n_T} \times 100 \qquad (1)$$

Results

Time-series plots of an individual bird's harness temperature and house temperature for Day 8 and Day 14 are shown in Figures 5 and 6, respectively. Harness temperature is clearly elevated above room temperature for both days. Mean harness and room temperatures for each day are listed in Table 1.

Overall least squares means for harness and room temperatures were 29.2 and 33.0°C, respectively and were significantly different (P < 0.0001). The estimated difference between harness and room temperature was

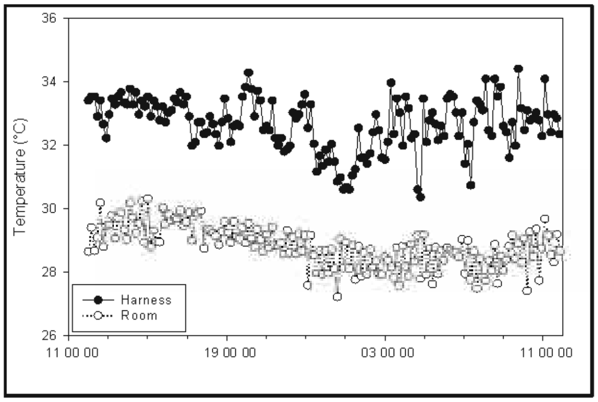

Fig. 5: Time series plot for an individual bird harness (Bird #2) for Day 8.

Table 1: Daily mean temperatures for bird harnesses and room. All temperatures are listed with their respective standard errors. Mean temperatures represent an average of

Day	Harness (°C)	Room (°C)
8	32.9 ± 0.01	28.8 ± 0.01
9	32.7 ± 0.01	29.0 ± 0.01
10	32.9 ± 0.01	29.3 ± 0.01
11	33.1 ± 0.01	29.4 ± 0.01
12	33.1 ± 0.01	29.3 ± 0.01
13	33.2 ± 0.01	29.2 ± 0.01
14	33.2 ± 0.01	29.4 ± 0.01

where: n_T = number of observations within a given 1°C temperature bin for histogram analysis.

3.8°C with a standard error of 0.06°C; the least significant difference was calculated as 0.15°C.

Percentage relative frequency of temperature measurements were determined using histogram analysis. Fig. 7 shows the histogram plots for the harness and house. The largest percentage relative frequency for the harnesses (44.4 %) and house temperatures (35.0%) were from the 34-35°C and 30-31°C bins, respectively.

Discussion

As seen in Fig. 7, the temperatures most frequently observed from the harnesses were between 34 and 35°C. In two other temperature preference studies (Baxter *et al.*, 1970; Aslam and Wathes, 1991) black globe temperatures were used as measurements and as such, a direct comparison cannot be made between the results presented here and the previous studies. However, Aslam and Wathes (1991) noted that black globe temperature may not be the most appropriate measure of chicks' thermal comfort. Baxter *et al.* (1970) conducted their experiment in a room held at 15.5°C and chicks in that study showed a preference for globe temperatures of 25.7°C. Aslam and Wathes (1991) found chicks preferred globe temperatures of 28 to 30°C

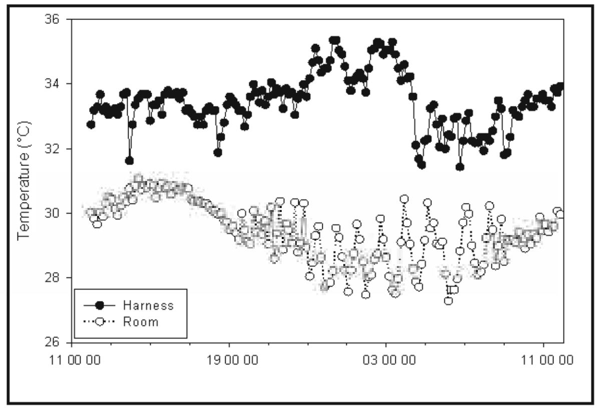

Fig. 6: Time series plot for bird harness (Bird #2) for Day 14.

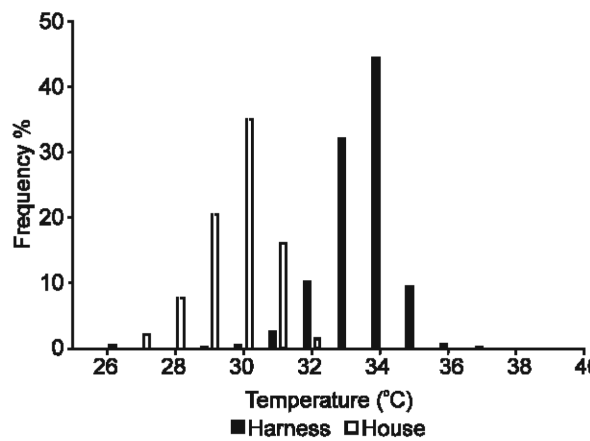

Fig. 7: Histogram plot of harness and house temperatures.

in a room held at 28.0°C (day 7) to 26.1°C (day 14). There is no indication of the air temperature surrounding chicks in either study.

It should be noted that the temperature measured by the harness does not directly reflect the house temperature, but rather the micro-environment surrounding the chicks. As this house was deliberately held at a lower temperature than that typically recommended during brooding, chicks were huddling together for warmth. Periodically the chicks would disperse to cool themselves and this behavior can be noted in the cyclic nature of the harness temperature throughout the day (Fig. 5 and 6). Aslam and Wathes (1991) also observed similar behavior of chicks moving between different zones within a house to heat and cool themselves.

The air temperature surrounding the chick is within ranges of brooding temperatures shown to elicit nominal performance during the first week of production. Although previous studies have recommended a reduction in air temperature for the second week (Harris, 1975; Charles, 1986; Deaton, 1995; Deaton *et al.*, 1996), birds tested herein maintained temperature around their bodies at higher temperatures than those recommendations from the former studies. However, it must be remembered that thermal conditions conducive to optimal production efficiency may be different than those preferred by the birds.

Conclusion: The micro-environment surrounding the broiler chick from 8 to 14 days of age was significantly warmer ($P < 0.0001$) than the air temperature of the room. Temperature preferences, defined as percentage of readings in a given temperature range, showed that 76.3% of all measurements taken by the harness loggers were in the range of 33 to 35^{o}C. Variation in harness temperature showed evidence of cyclic heating and cooling throughout the day. Further work should be directed at quantifying the contribution of radiant energy from the brooders to the chick's micro-environment and comparing production metrics between the air temperatures preferred here and current brooding guidelines.

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