Comparing The Thermal Environmental In Broiler Housing Using Two Bird's Densities Under Tropical Conditions

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ABSTRACT

Brazilian farmers have adopted high bird density associated to auxiliary management such as adapted tunnel ventilation system in order to optimize broiler productions and to provide thermal comfort for the reared birds. This research compared two distinct broiler's lodging systems in three commercial flocks and similar outside conditions using: a conventional housing system lodging 13 birds/m^2 (G1) and an adapted tunnel based on a combination of positive and negative pressure with side walls closed with curtains with broilers housed at density of 18 birds/m^2 (G2). Environmental variables such as dry bulb (DBT) and black globe (BGT) temperatures, relative humidity (RH) and inside air speed (AS) were recorded, while the temperature daily fluctuation (DF) and the effective temperature (ET) were calculated. The bird's behavior was observed and the broiler's weight gain and percentage of mortality were measured. Results showed that there was no difference in the physical environmental profile of both housings, even though they had distinct bird's densities. The values of relative humidity (RH) in both systems were higher than the ones found outside due to the use of fogging inside. Broiler's weight gain was not statistically different in both systems, however as total number of birds was higher in G2 the final results of meat production was higher in G2 than in G1. Better distribution of air flow over the birds in the adapted tunnel ventilation system G2 apparently alleviated the broiler's heat stress.

Keywords: broiler, heat stress, ventilation

1. INTRODUCTION

During the summer months in Southern Brazil, losses in mortality due to excess of heat inside broiler's housing can reach around 10% of the total production. Environmental control for poultry houses is generally provided by the use of fans and fogging; however most Brazilian broiler's housing still relies only on natural ventilation. Ideal poultry production requires a housing environment that provides adequate inside temperature and relative humidity, as well as promotes enough air circulation.

There are effectively a large number of variables affecting the micro-climate inside a bird's housing. Several authors have studied the influence of heat stress in broiler's performance under temperate and hot climate rearing since the early 80's (Esmay, 1982; Webster and King, 1987; Marder and Arad, 1989; and Nääs, 1994), and the influence of the physical microenvironment (temperature, humidity, light intensity, air velocity, etc.) on animal physiological responses and related performance has been demonstrated (Mount, 1979; Curtis, 1983; Deaton et al., 1997; Hamrita et al., 1998; Hamrita and Mitchell, 1999; Lacey et al., 2000). Controlling the physical micro environment in broiler production houses is an important element in optimizing the production process (Xin et al., 1994; Bottcher and Czarick, 1997; Gates et al., 1998, and Boni and Paes, 2000).

The combined effects of both variables temperature and relative humidity are critical in determining the bird's ability to dissipate heat and avoid losses caused by heat stress (Xin et al., 1994). Lambert et al. (1997) showed that is possible an expansion of the thermal comfort zone mainly with respect to the RH values, when the wind flow is turbulent (forced ventilation above 2.0 m/s) in the environment. Czarick and Lacy (1999) proved that the effective thermal sensation expressed by broilers in different ages is directly proportional to the wind speed inside the lodging facility, alleviating considerably the heat stress in adult birds.

Ventilation (both natural or forced) moves air into and out of the building carrying fresh air in and removing heat, moisture, and contaminants added to the air by the birds and the litter. Airflow over the birds can help cool them in warm weather by decreasing the effective temperature (Bottcher and Czarick, 1997) and increasing their resistance to thermal stress. Ernst (1995) shows the positive effect of high wind flow over the birds on physiological parameters, such as respiratory frequency and deep body temperature, mainly when the environmental temperature reach levels above the thermoneutral zone (30ºC). Ventilation rate should be minimal in cold weather as cited by Boni and Paes (2000), and the airflow over litter or manure in cool weather may be helpful in controlling moisture and ammonia levels.

Evaporative cooling, either by fogging or wet pads reduces dry air temperature but increases relative humidity which can provide much-needed cooling in hot weather, but it may turn the environment inside too humid for the birds. In order to reach the ideal broiler production environment the use of cooling system and fans are required especially when the broilers are housed under high bird's density (Bottcher and Czarick, 1997). Gates et al. (1998) showed that the use of tunnel ventilation (with negative pressure) is an economical alternative for producing broilers especially during summer time in the US.

2. OBJECTIVE

The objective of this research was to compare the resulting housing environmental (dry bulb and black globe temperature, relative humidity and air velocity), and the broiler daily gain and mortality in two poultry rearing facilities adapted to tropical conditions. It was also compared the housing environment with the outside environmental conditions

3. MATERIALS AND METHODS

The analysis was based on two treatments: one used an association of natural and forced ventilation added to fogging system, and a bird's density of 13 birds/m^2 (treatment 1=G1); the other used an adapted tunnel ventilation, based on a combination of positive and negative pressure ventilation associated to fogging with the sidewalls closed with curtains and a broiler's density of 18 bird's/m^2 (treatment 2=G2), and the outside environment was recorded.

The two analyzed commercial broiler housing were located at Rio Claro county, West of São Paulo State, Brazil, both oriented East-West, measuring 115 m long, 12 m wide and 3.2m average height (3.6m center to 2.8m eave); and used fiber cement roof tiles coated with white painting. The bedding was of wood shaving and the sidewalls were of blue plastic curtains. G1 housing (Figure 1a) had 6 (1HP fixed 1.20m from floor) fans inside all facing the West side, following the pattern of the natural wind flow, and two lines of fogging. The G2 housing (Figure 1b) was an adapted tunnel ventilation combining both positive and negative pressures using 8 (0.5 HP fixed 1.20 m from floor) axial positive pressure fans inside and 4 (1.5 HP fixed 0.60m from floor) negative pressure fans on the East wall for removing the inside air, and 5 (0.5 HP fixed 0.60m from floor) axial fans on West wall for pushing the incoming air inside the housing. Two lines of fogging were used inside as well as the complete closure of the building with additional PVC blue curtains for allowing the negative pressure to work.

(a) (b)

Figure 1. View of the exhausting fans (a) inside G2, and axial fans and side curtains (b) inside G1.

Each house was divided in three equal parts (box 1 to 6) for avoiding the birds to migrate, as shown in Figure 2. In the geometric center of each box and above the broiler's head (50 cm) the environmental data was collected.

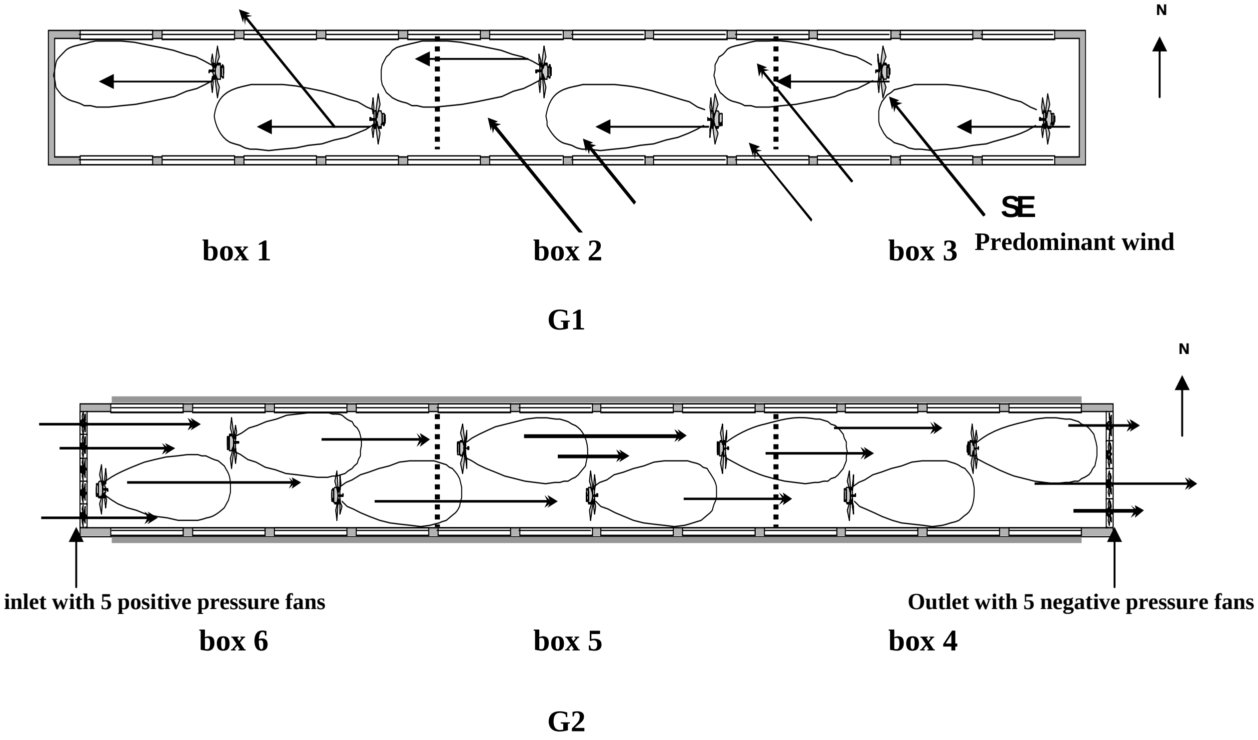

Figure 2. Schematic of the air flow and box division in each treatment.

In G1 all cooling systems (fans and evaporative cooling) were turned on automatically when environmental temperature reached 28ºC. A controller was used for starting part of the ventilation system (2 exhausting fans plus 5 axial fans-2 at the West wall and 3 inside the housing) when the inside temperature in G2 reached 25 ºC. As soon as the inside temperature reached 28 ºC the second part of the system was turn on (8 axial fans- 2 at West wall and 5 inside housing; and the 2 remaining exhausting fans plus the fogging system). In both systems the fogging was only turned on if relative humidity was below 80%. In order to assure the system to work in the programmed way two sensors of dry bulb and wet bulb temperatures were placed at the center of the building 40 cm above the floor.

Data were recorded in three flocks beginning on February 3rd 2000 until March 14th 2001. The recorded outside environmental temperatures and relative humidity during the three flock growing period were previously submitted to an analysis of variance (ANOVA) for (α=0.05), showing the similarity of dry bulb temperature (DBT) and relative humidity daily profile. The flocks were then statistically treated as repetitions (Table 1). Bird's nutrition management was similar for both housing during the experiment.

Table 1. Number of birds housed and density in each flock used during the experiment

Flock	Number of birds		Flock density(birds.m^{-2})		Total of birds
	G1	G2	G1	G2	
1	18,463	25,675	13.38	18.61	44,138
2	18,206	25,195	13.19	18.26	43,401
3	18,930	26,170	13.72	18.96	45,100
Average	18,533	25,680	13.43	18.61	44,213

Avian® broilers were reared for nearly 45 days in each flock, and environmental data were recorded starting from day 21 from February to March 2000, March to April 2000, and February to March 2001. Statistical analysis was based with the flocks during these three specific periods. Weight gain was recorded by samples of 2% of the flock (nearly 500 birds in house G2 and 360 birds in house G1), and mortality data were recorded daily in each box.

Measurements of environmental data were taken with datalogger DIDAI® programmed for recording every 30 min the dry bulb (DBT) and black globe (BGT) temperatures, as well as the relative humidity (RH) in the geometric center of the six boxes inside G1 and G2, and in the outside environment (control) with protection from direct radiation. The DBT daily fluctuation was calculated as the difference between the maximum and minimum DBT. Wind speed was measured twice during the day, in the morning and in the afternoon, inside the boxes in three distinct locations using digital anemometer Alnor® at 9:00 A.M. and 3:00 P.M, and average values were calculated. The estimated effective temperature felt by the birds was calculated from Czarick and Lacy (1999) and Boni and Paes (2000), as shown in Eq 1. Bird's behavior was observed during the trial for 15 min in the afternoon (Bizeray et al., 2002) by focusing specifically in signs of panting and prostration.

$$EET=1,03*(0,85^2)-7,28*0,25+26,5 \qquad \text{Eq 1}$$

The two technological concepts (G1 and G2) were statistically compared in a randomized way considering one factor as the housing concept with two treatments G1, G2 as described. The software SAS® was used for performing the Tukey test in order to identify the differences between treatments.

4. RESULTS AND DISCUSSION

Results shown in Table 2 indicate that both cooling concepts reduced the dry bulb temperature inside the housing (26.07 and 27.47ºC) when compared to the outside temperature (28.35ºC). From the statistical data DBT in G2 (with higher bird's density) did not differ from DBT in G1 (with lower bird's density), despite the fact that the sensible heat generated inside G2 was larger due to the higher bird's density. When using tunnel ventilation (G2) it is created some stable pattern of air movement and effective temperature distribution in a building. Bottcher and Czarick (1997) present tunnel ventilation as an efficient alternative in reducing heat stress in adult broilers due to the uniform and continuous air flow. When outside temperature exceed a level of 23-26°C, it starts to be difficult to keep indoor temperature within the limits of thermoneutral zone by air exchange alone. In this case some additional methods of lowering the effective temperature in a building needed to be used.

Table 2. Environmental average data results for the two treatments and the control for three flocks

Treatment	DBT (ºC)	EET* (ºC)	DF (ºC)	BGT (ºC)	AV (m/s)	RH (%)
G1	26.07^{a}	25.24	6.93^{a}	26.19^{a}	0.25^{b}	89.74^{b}
G2	27.47^{ab}	25.43	6.43^{a}	28.06^{b}	0.85^{a}	89.70^{b}
Outside	28.35^{b}	-	9.85^{b}	28.19^{b}	0.12^{c}	85.77^{a}
SD	2.52	-	2.81	2.53	3.82	3.15

Average values with same letters do not differ by Tukey test (α=0.05).

* Estimated from Czarick and Lacy (1999) and Boni and Paes (2000).

DBT=environmental dry bulb temperature; EET= estimated effective temperature; DF= daily temperature fluctuation; BGT= Black Globe environmental temperature; AV= air velocity; RH= environmental relative humidity; SD= standard deviation of recorded values.

There was not found statistical positive correlation between the type of ventilation and the variable RH, even though in both housing systems data were found higher than in the outside environment probably due to the use of fogging in both G1 and G2 as DBT was higher than the thermoneutral temperature. The values of RH were found lower outside than inside during the daytime, increasing in late afternoon due to the afternoon rain that occurred nearly daily during the trial. The association of the outside increase in RH added to the humidity from the litter and latent heat from the birds led to relative humidity values inside the housing above the desirable ones.

It was also found a large DBT fluctuation outside (9.85°C) while inside the housings the largest measurement of DBT fluctuation (6.93 °C) was found in G1. This data was significant regarding the consequence of exposure to thermal stress in birds, as described by Macari and Gonzales (1990) who found highest incidence of metabolic diseases such as ascitis and sudden death related to environmental temperature fluctuations above 5 °C. Deaton et al (1997) also observed the lowest feed conversion in adult birds when DBT varied cyclically from 23.9 to 35°C, when compared to a steadier environment.

Average value of BGT was found smaller inside G1 (26.19°C) than outside (28.19 °C) probably due to the lower amount of lodged birds. As birds emit radiant heat the values of BGT inside G2 were probably influenced by the higher bird's density. According to Esmay (1982) and Nääs (1994) values of BGT can be negative on the bird's performance.

Broilers reactions to poor thermal conditions often affect the growing response which is not always adequate to what the birds actually need. Statistical analysis results of average daily weight gain in this experiment are shown in Table 3. It was found that the environment resulting from the cooling devices used in both G1 and G2 had the same effect in the bird's weight gain. For accumulated mortality data the best absolute results were found for G2 (2.7%) with the adapted tunnel ventilation, while the G1 presented a value of 3.0% may be due to a more balanced and stable ventilation over the birds, and for maintaining the inside temperature's fluctuation low, agreeing with Barnwell (1997).

Table 3. Broiler's weight gain and accumulated mortality for treatments G1 and G2 during three flocks

Treatment	Average broiler's weight (kg)			AG (kg)	AM (%)
	day 21	day 28	day 35		
			G1		
Box 1	0.74	1.16	1.61	0.251	
Box 2	0.78	1.22	1.67	0.262	
Box 3	0.77	1.22	1.69	0.263	
Average	0.76	1.20	1.66	0.259^a	3.0
			G2		
Box 4	0.75	1.22	1.64	0.258	
Box 5	0.72	1.27	1.68	0.262	
Box 6	0.74	1.18	1.72	0.260	
Average	0.74	1.22	1.68	0.260^a	2.7

Average values with same letters do not differ by Tukey test (α=0.05).
AG= average broiler's daily gain; AM= accumulated mortality on day 42.

The broiler's average weight gain was the same in both treatments, even though they differ in absolute values within the boxes. The accumulated mortality was higher in G1. The weight density in G2 led to 30% more meat production, and the evolution of the average weight density can be seen in Figure 3.

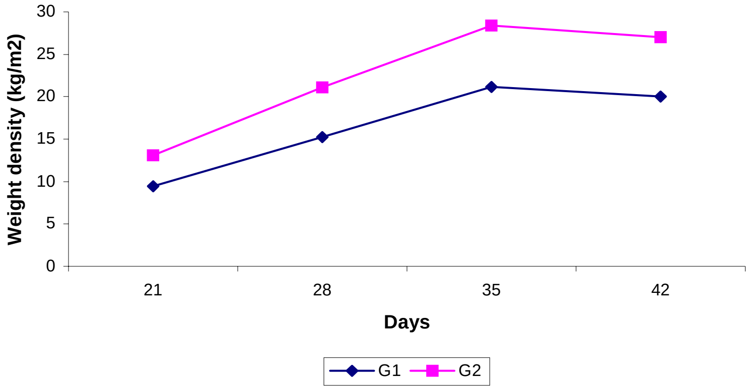

Figure 3. Weight density in both treatments in three flocks

Boni and Paes (2000) reported that the thermal sensation of birds may change when exposed to high wind speed. The air velocity inside G2 was higher than in G1 which led to estimated effective temperature (EET) quite similar in both treatments, and the thermal sensation for the birds was similar, even though with higher bird's density, agreeing with Webster and King (1987), Czarick and Lacy (1999), and Boni and Paes (2000). The birds were often panting and prostrated during the maximum recorded DBT (that happened in the afternoon) inside G1, while inside G2, even though with highest bird's density, normal behavior and resting was observed at the maximum DBT, as shown in Figure 4.

Figure 4. Behavioral response to thermal environment in G1 and G2

5. CONCLUSIONS

One of the most common methods of lowering the effective temperature in poultry housing under hot temperatures is to increase air velocities to improve convection heat exchange between birds and adjacent air. The use of higher air flow over the birds in the adapted tunnel ventilation system G2 led to a better dynamic air conditions alleviating the broiler's heat stress, especially taking into account the larger bird's density housed in that system.

The efficiency of ventilation and fogging systems which reduce heat stress for adult broilers should be verified on the basis of bird's behavior response, mainly panting and prostration. Possible differences between various systems can be best recognized at sudden effective temperature changing when it is relatively easy to observe the reaction of chickens as a group as well as the individual different responses.

As the initial investment in using adopted tunnel ventilation is higher, further economical analysis should be done to compare the cost/benefit of using this system. Also welfare evaluation should be pursued in this particular system as bird's density is high.

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