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Evaluation of Broiler Breeder Housing in High Temperature Brazilian Conditions

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Abstract

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Keywords

Conditioning Systems, Thermal Comfort, Environment for Broiler breeders, Open facilities, Litter Moisture content, Evaporative Cooling Systems

Disciplines

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Evaluation of Broiler Breeder Housing in High Temperature Brazilian Conditions

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Summary: An experiment was conducted to investigate the effects of different cooling systems on bird thermal comfort, litter moisture content and the performance of broiler breeders, housed in open facilities at high temperatures conditions in Brazil. The study used Hubber lineage birds, from 26 to 37 weeks of age, in summer and fall conditions, in the Minas Gerais State, Brazil. Two facilities were used, with similar dimensions and construction characteristics, oriented in an east-west direction. Six replicates of six different systems of environmental control were evaluated: (fan jet with polytube and evaporative cellulose pad material, FJS; roof sprinkling (exterior), RSS; internal fogging system, IFS; two horizontal mixing fans directing air into the room, MFS; two roof-top wind-driven turbine ventilators, RVS; and a conventional system as the control, CTL, with ventilation provided solely by wind and no additional cooling. Hatchability, AH, was measured weekly. Results demonstrated that the FJS, IFS and MFS systems, in this sequence, performed best, presenting reduced BGHTI values and improved AH as compared to the other systems.

Results obtained from the RVS and the CTL systems were markedly inferior. Litter moisture content (MC) was least in the MFS system while greatest in the FJS system.

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ABSTRACT

The importance of high quality facilities for broiler breeders is critical for poultry production, and these systems are largely responsible for the birth and growth of the modern world poultry industry. However, in tropical and subtropical climates, for example in much of Brazil, high ambient air temperature and relative humidity can generate conditions of continuous poor thermal comfort to the birds. An experiment was conducted to investigate the effects of different cooling systems on the bird thermal comfort, litter moisture content and the performance of broiler breeders, housed in open facilities at high temperatures conditions in Brazil. Two facilities were used, with similar dimensions and construction characteristics, oriented in an east-west direction. Six replicates of six different systems of environmental control were evaluated:, (fan jet (300 m^3 h^{-1}) with polytube and evaporative cellulose pad material, FJS; roof sprinkling (exterior), RSS; internal fogging system, IFS; two horizontal mixing fans (0.9 m) directing air into the room, located on upwind side of house, MFS; two roof top wind-driven turbine ventilators, RVS; control, with ventilation provided solely by wind and no additional cooling, CTL. The purpose of this study was to investigate the effect of the different cooling systems on the environmental thermal comfort (evaluated by Black Globe and Humidity Temperature Index, BGHTI, taken at two hour intervals, from 8:00 a.m. to 6:00 p.m.). Production performance of broiler breeders (evaluated by egg hatchability, AH, was measured weekly. The study used Hubber lineage birds, from 26 to 37 weeks of age, in summer and fall conditions, in the Minas Gerais State, Brazil. The results were interpreted statistically by means of analysis of variance and regression, and the averages of the qualitative factors were compared with F and/or Tukey tests, at ($p < 0.01$) and ($p < 0.05$), respectively. The results demonstrated that the systems equipped with FJS, IFS and MFS, in this sequence, performed best, presenting smaller BGHTI values and higher TE values as compared to the other systems. Results obtained from the RVS and the CTL systems were markedly inferior. For litter moisture content (MC) the MFS system was superior and FJS was least desirable.

INTRODUCTION

The environment in which birds are raised constitutes a decisive factor in the success or failure of a poultry operation, and housing for broiler breeders is one of the most important aspects of modern poultry systems, responsible in large part for the birth and growth of the world poultry industry.

Among all possible environment factors, air temperature, relative humidity, thermal radiation, and air movement most directly affect broiler breeders because they affect maintenance of homoeothermy. The probability of high productivity is reasonable only if these conditions are close to optimal. Out of the thermal comfort zone, birds must make more drastic physiological adjustments to maintain constant core body temperature. This in turn reduces production performance, because dietary energy and nutrients are not used for growth and development, but rather to produce or to dissipate heat (Penz, 1991).

When exposed to thermal stress, feed consumption is reduced; consequently, there is a reduction in the number and weight of eggs produced, quality of the egg shell, a reduction in fertility of both males and females, reduction in hatch percentage and chick weight at hatch (Campos 1995, 2000).

Another important factor to consider is litter moisture content (MC). Values of litter MC can reach 20-30%, and in conditions of high air temperatures, can induce ammonia production and volatilization which can be detrimental in high concentrations to animal health and production (Baiao, 1995; Gates et al., 2002).

Naturally ventilated housing systems are quite prevalent in Brazil. Several alternative designs are suggested to maintain thermal comfort for birds in these facilities. Under extreme conditions, and especially for valuable broiler-breeder flocks, it is desirable to assess additional cooling methods as part of these designs. Such systems include: fan jet with polytube and evaporative pad material; roof sprinkling; internal fogging system; horizontal mixing fan directing air into the room; roof top wind-driver turbine ventilators (Tinoco 1995, 2001). These cooling systems can be used in open facilities for many types of animal production, and they have been adopted in Brazilian aviculture. However, the efficiency for each of these processes in the improvement of the thermal comfort and, subsequent effects on the litter moisture content (MC) and in the performance of broiler breeders for the climatic conditions of Brazil have not been investigated.

An experiment was conducted to investigate the effects of different cooling systems on bird thermal comfort, litter MC and, consequently, on the performance of broiler breeders, housed in open facilities and in high temperature conditions in Brazil. Five different strategies for providing additional thermal conditioning were compared to the standard system (wind induced natural ventilation). These other systems are described below. The purpose of this study was to investigate the effect of the different cooling systems on thermal comfort (evaluated by Black Globe and Humidity Temperature Index, BGHTI, taken in two hour intervals, from 8:00 a.m. to 6:00 p.m.), on the litter moisture content (MC) and on the production performance of broiler breeders (evaluated by egg hatchability, AH, measured weekly).

MATERIALS AND METHODS

This work was conducted at a commercial poultry farm in Minas Gerais State, at a location with altitude of 742 m, located at latitude 18° 51´S, longitude 48°10´W, during summer and fall conditions. The research was carried out with 12,960 broiler breeders, Hubber lineage, from 26 to 37 weeks of age. Six different conditioning systems, with six replications, were used in the two similar buildings. Buildings were metal framed, open-sided, naturally ventilated houses with wood shavings litter over a concrete floor. These buildings were 40 m apart, oriented on East-West, with similar construction materials and dimensions (205 m long x 13.5 m wide and 3.5 m roof ridge height and 1.7m eave height. The roof was covered with clay tile and did not have a ridge vent. A total of 36 cross sections of the houses comprised the experimental areas, each 67.5 m^2 (dimensions 13.5 x 5.0 m), and were configured according to industry practices. Six different environment conditioning systems were used:

1. fan jet (300 m^3 h^{-1}) with polytube (0.9m) and evaporative cellulose pad material, FJS;
2. roof sprinkling (exterior), RSS;
3. internal fogging system, IFS;
4. two horizontal mixing fans (0.9 m) directing air into the room, located on upwind side of house, MFS;
5. two roof top wind-driven turbine ventilators (0.4 m each), RVS, and
6. control, ventilation provided solely by wind with no additional cooling, CTL

The forced ventilation system, MFS, fans were activated at 8:00 a.m. daily, and any time that air temperature exceeded 25ºC and/or if ammonia odor was observed. The evaporatively cooled fan-jet, FJS; and the fogging system, IFS, were each activated when air temperature exceeded 25ºC, and remained working while the relative humidity of the air was less than 80%. Above this humidity, fogging was shut off and, in the case of FJS, only the fans continued to operate to remove excess humidity and gases.

2.1 Bird Handling in the facilities

The handling used for the broiler breeders was identical in all the zones. The birds were of identical lineage, with similar age and uniform weights, housed in the same density by area (from 5 to 5.5 birds·m^{-2} and a proportion of 1 male for each 8 to 10 females (Baião, 1995; Campos, 2000).

2.2. Egg Handling

The eggs were gathered by hand five times a day, stocked in plastic receptacle, and identified by treatment. They were separated for category and then moved to the "eggs rooms", where they were classified and disinfected after each collection.

For determination of the incubation rate, 86 eggs were randomly selected from each treatment and incubated. This procedure was conducted during the 34th to 37th week of age of the broiler breeders, during the production phase between initial and maximum egg production.

2.3. Instruments and measurements

Measurements were taken every two hours from 8:00 a.m. to 6:00 p.m., inside each experimental area, external area of the facilities, and in a meteorological shelter.

Measurements included dry bulb and wet bulb temperatures, black globe temperature, and air velocity. Maximum and minimum daily temperatures were also recorded.

The Black Globe and Humidity Temperature Index (BGHTI) was determined from environment measurements. The weekly values and the averages of BGHTI were used as to assess the usefulness of each environment control treatment, allowing an evaluation of the influence of the conditioning systems on the thermal comfort. Litter moisture content (MC, %), was measured weekly, for nine consecutive weeks, in each one of the six environmental conditioning systems.

To evaluate the effects of different conditioning systems on productive performance of broiler breeders, the percentage hatch rate (hatchability) was recorded weekly. The results were interpreted statistically by means of analysis of variance and regression. The averages of the qualitative factors were compared by F and/or Tukey tests, at ($p<0.01$) and ($p<0.05$), respectively.

RESULTS AND DISCUSSION

3.1. Evaluation of the thermal comfort – Black Globe and Humidity Temperature Index

The summary of the analysis of variance for effects of systems on mean BGHTI are presented in Table 1. There was a significant difference ($P<0.01$, Table 1) among the values of BGHTI, for the effects of conditioning systems (S), among the hours of observation (H), and interaction S x H. That means that the two variables (S and H), acted together on the results of BGHTI, whose average values are presented in the Table 2.

It is observed that the values of BGHTI increased among the systems, in the following order, FJS, IFS MFS, RSS, RVS and CTL, and thus the thermal comfort was decreasing in the same order.

TABLE 1 - Effects of the Different Conditioning Systems (S) and of the Hours (H), with Relationship to the Hourly Black Globe and Humidity Temperature Index, BGHTI.

Source	degrees of freedom	MEAN SQUARE BGHTI
Systems (S)	5	21,1584 **
Residue (a)	24	1.2015
Schedule (H)	5	120.1452**
S x H	25	1.5435 **
Error (b)	120	0.1448

* * Significant F at the Level of 1% of Probability for Tukey test

TABLE 2. Mean BGHTI for the six conditioning systems in each hour of day.

HOUR	ENVIRONMENT CONDITIONING SYSTEMS					
	IFS	FJS	CTL	RSS	RVS	MFS
8:00 a.m.	74.6, a	74.3 a	74.4 a	74.4 a	74.36 a	74.2 a
10:00 a.m.	76.7 a	76.3 b	77.5 a	77.3 a	77.51 a	76.6 a
12:00 a.m.	77.9 c	77.4 c	79.8a	80.0 a	80.31 a	79.1 b
2:00 p.m.	78.7 c	78.1 c	81.5 a	80.8 ab	81.5 a	79.9 b
4:00 p.m.	77.8 cd	77.1 d	79.9 a	79.5 ab	79.9 a	78.6 bc
6:00 p.m.	77.2 bc	76.4 c	78.4 a	78.1 ab	78.4 a	77.2 bc

Row means with the same letter do not differ from one another, (p< 5%) of probability, for the Tukey Test.

From Table 2, BGHTI at 8:00 a.m. was similar for the different systems since the systems were not operating, and each area behaved the same. It was observed that at 10:00 a.m., the BGHTI in the FJS treatment was significantly less than that in the other systems. From 10 a.m. to 4 p.m., the values of BGHTI obtained in FJS, were less than all the other systems, with the exception of IFS in the hours between 12:00 a.m. and 2:00 p.m., although in this case, the absolute values of BGHTI in FJS were reduced. The most reduced values of BGHTI at 6:00 p.m. were obtained with IFS, FJS and RVS.

The smallest values of BGHTI for all the conditioning systems occurred in the morning, increasing until approximately 3:00 p.m. and decreasing until the end of the day. This daily behavior was regularly observed during such tests, as mentioned by Tinôco (2001), and demonstrates the tradeoffs between solar building load (which peaks near noon) and ambient air temperature (which peaks about 4pm). Thus, within these structures ambient temperatures dominate the BGHTI although the contribution from solar radiation is quite significant.

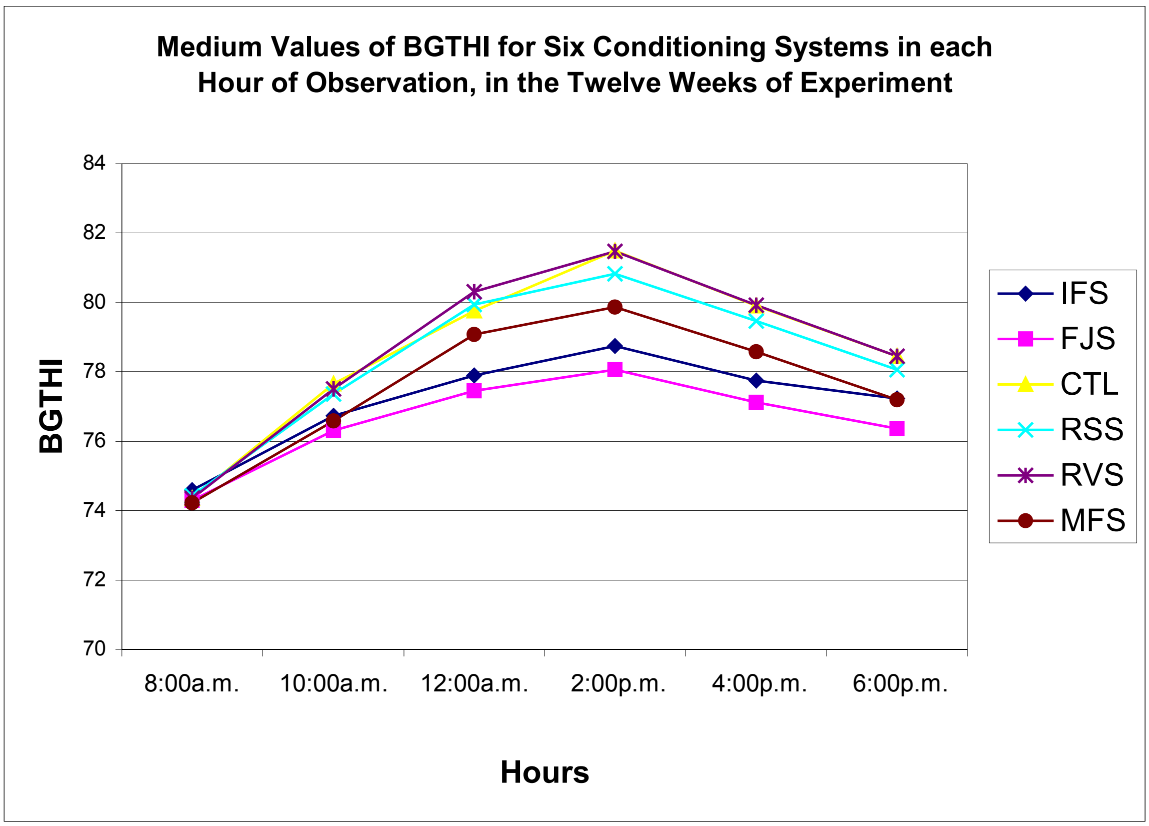
Table 2 also shows that until 12:00 a.m. (noon), there is minimal ventilation system influence on BGHTI. However, from 12:00 a.m. until 4:00 p.m. the IFS and FJS were superior, which suggests that evaporative cooling was the most effective means of reducing BGHTI in the hottest hours of the day. At 6:00 p.m. the MFS, IFS and FJS were similar in ability to reduce BGHTI. MFS only differed from IFS at 12:00 p.m. and 2:00 p.m., realizing greater values of BGHTI (approximately 1.2 units). In comparing the IFS, FJS and MFS designs (representing fogging without forced ventilation, evaporative cooling with ventilation, and ventilation alone) these results suggest that the combination of evaporative cooling and ventilation provides the lower values of BGHTI during most of the day.

With regard to Control, RSS and RVS systems, there were no differences during the entire day period. That is, neither roof ventilation nor sprinkling had any measurable improvement on thermal comfort of the birds. However, during the late afternoon, there was not a significant difference between roof sprinkling and the MFS system, although the magnitude of difference was greater than 1 unit (with MFS providing lower BGHTI than the RSS).

Table 2 shows that starting from 10:00 a.m., in all the systems, except FJS at 6:00 p.m., the maximum values of BGHTI were 77.0 and 75.0, as also observed by Piasentin (1983) and Tinôco (1995, 2001). Thus, although the conditioning systems improved the environment, once conditions were improved over those observed in the control system, none was capable of attaining thermoneutral conditions within the house. This result can be explained by the fact that the all studied facilities are totally open, as is usual in broiler breeder facilities in Brazil. Therefore, the external and internal environment constitutes an open thermodynamic system; as the temperatures of the external environment were high, or above the comfort zone in everyday of collection of data, these values masked the efficiency of the studied systems.

Comparing the CTL, RVS, RSS and MFS systems, starting from the 12:00 p.m. until the end of the afternoon, MFS was best, which suggests that air exchange is important in the hottest hours of the day. There was significant difference among the systems at 12:00 p.m., with smaller values of BGHTI in MFS, and that on this schedule ventilation is more effective in the improvement of the thermal comfort than the reduction of the temperature possibly obtained with the aspersion of water over the cover system, RSS.

FJS was considered the most efficient system in terms of thermal comfort, followed by IFS, MFS and RSS relative to BGHTI. The RVS and CTL were the least efficient. Figure 1 illustrates the present discussion.



3.2. Litter Moisture Content (MC)

The summary of the variance analysis for the averages values of litter moisture content (MC), in %, obtained weekly, for nine consecutive weeks, in each of the six environment conditioning systems, and in each level of energy in the diet is related in the Table 3. It is verified that there was not significant difference at the level of 5% of probability, for the test of F, among the levels of energy in the ration and in the interaction N x S, demonstrating that these act independently on the values of MC.

It is also verified, that there was significant difference, (p<1%) among the different conditioning systems. The averages of these treatments are demonstrated in the Table 4, which shows that IFS, FJS, CTL, RSS and RVS, didn't differ statistically from each other; however, the MFS, experienced the lowest (34.48%).

Although the values of the litter MC are not statistically different, in five of the conditioning systems, those were decreasing in the following order: IFS, FJS, RSS, RVS and CTL, with average values in nine weeks of observation of 41.45 %; 38.90 %; 37.94 %; 37.13 %; 36.85 %, respectively, suggesting that an improvement in the litter moisture content, therefore reducing the possibility of ammonia emission for the atmosphere. However, in all the systems of thermal conditioning, the values of the litter moisture content was above those considered to be desirable for the birds (Baiao, 1995, recommends values between 20 and 30%). According to Baiao, values of litter MC greater than 30% induce the largest ammonia production, which is extremely harmful to the animal production and air quality inside the building or emitted to the atmosphere.

TABLE 3 - Summary of the Analysis of Variance to the Effects of the Six Different Environment Thermal Systems (S) and the Energy levels in the food (2750, 2850 and 2950 kcal/kg), with Relationship to the Average of the Values of the Litter Moisture Content (MC), in %.

Source	Degrees of Freedom	Mean Square Litter Moisture Content (MC), (%.)
block	7	390.5
levels (n)	2	85.5
systems (s)	5	129.4 **
n x s	10	9.0
error	119	30.7
CV (%)		14.65

* * Significant at the level of 1% of probability, for the test F

TABLE 4 - Average Values of Litter Moisture Content (MC), in %, for the Six Different Environment Thermal Systems, in the Nine Weeks of Observation.

SYSTEMS	(MC)
IFS	41.45 a
FJS	38.90 a b
CTL	37.13 a b
RSS	37.94 a b
RVS	36.85 a b
MFS	34.48 b

Means with the same letter, do not differ from one another, at the level of 5% of probability, for the Tukey test.

3.3. Evaluation of the Broiler Breeders Performance – Average Hatchability (AH)

The summary of the analysis of variance for hatchability, AH, in % of total of incubated eggs, obtained from 34 to 37 weeks of age, in four consecutive weeks, for the six thermal conditioning systems and for three different levels of energy in the feed (N), is related in Table 5.

TABLE 5 - Summary Analysis of Variance of the Effects of the Thermal Conditioning Systems (S) and of Energy levels in the feed (2750, 2850 and 2950 kcal/kg), on the hatchability, AH

Source	degrees of freedom	Mean Square Average Hatchability, AH, in %
BLOCK		
LEVEL (N)	2	0.91291
SYSTEMS (S)	5	15.7555 *
N X S	10	4.9233
ERROR	54	5.5296
CV (%)		2.57

* * Significant at the level of 1% of probability, for the test F

It is observed in Table 5, that there was significant difference ($P < 0.05$), among the different thermal conditioning systems. The averages of the treatments is shown in Table 6, which verifies that IFS, FJS, CTL, RSS and MFS were not statistically different from each other. However, RVS presented more reduced values. Table 6 also shows that FJS provided the best hatchability, with average value of 93.1 % while RVS provided the worst rate, 89.7%. Although the values of average hatchability are not statistically different, they decrease in the following order: FJS, IFS, MFS, RSS, CTL and RVS. This order is identical with BGHTI, suggest that the hatching rate is higher under improved thermal conditions.

TABLE 6 – Average Values of hatchability (AH), in %, for the Six Different Environment Thermal Systems, in the Four Weeks of Observation.

SYSTEMS	Hatchability (AH), in %
FJS	93.08 a
IFS	92.19 a b
MFS	91.61 a b
RSS	91.22 a b
CTL	90.91 a b
RVS	89.72 b

Means followed by the same letter do not differ at the level of 5% of probability, for the Tukey test.

CONCLUSIONS

The following conclusions can be drawn from this work:

a) The BGHTI inside the facilities was influenced by the environment conditioning system, and the best thermal comfort, represented by smaller values of BGHTI, were obtained in the environment with FJS, followed by IFS and MFS. The worst results were obtained in the environment with CTL, and RVS.

b) The litter moisture content (MC) was also influenced by the environment conditioning system. Elevated values of MC were observed in IFS and FJS; the lowest value was found in MFS.

c) The environment obtained under the different conditioning systems significantly influenced the production performance of the broiler breeders, as represented by egg hatchability ($p<0.05$). The FJS provided the best hatchability, while RVS provided the worst. Hatchability from the other systems, while not statistically different, followed the same order as the BGHTI, further suggesting the importance of thermal comfort on broiler breeder productivity.

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